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SID 62-170-5

APOLLO WIND TUNNEL PROGRAM REPORT

NAS9-150

July 1963

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NORTH AMERICAN AVIATION, INC.
SPACE and INFORMATION SYSTEMS DIVISION

FOREWORD

This report was prepared under the NASA Apollo Contract NAS9-150 and represents a joint effort of the Apollo Aerodynamics Group of the Space and Information Systems Division and the Wind Tunnel Projects Group of the Los Angeles Division. This report will be revised semiannually.

ABSTRACT

Test objectives, test facilities, models required, and tunnel test hours for the Apollo program are discussed. The proposed schedule of wind tunnel tests, tests already accomplished, and the relationship of the test program to the design phases of the space vehicle development are included.

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I. INTRODUCTION

The scheduled wind tunnel test program will supply data on aerodynamic heating, stability during abort, entry and recovery, effects of center-of-gravity offset and heat shield ablation, interaction between separating bodies during escape operations, aerodynamic loads throughout the flight regime, and other problems that must be solved for the successful design of the Apollo.

A highly concentrated wind tunnel program is required to meet the internal release dates. This program will provide the necessary experimental data for the evaluation of the design and wherever possible will use large models for testing at Reynolds numbers approaching flight conditions. Detail design data will be generated and detail design problems will be investigated including tests of the Apollo recovery system, tests of the control jet interaction and effectiveness, and tests to assure compatibility between the command module and the service module and other booster components.

Completed wind tunnel tests of the Apollo are summarized in Tables 1, 2, and 3.

Table 1. Summary of Force Tests Actually Conducted

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. Twenty combinations of the nine escape motors and four tower structures were tested.	SAL	18 Feb 1962 to 6 Mar 1962	54.1	1.57, 1.88, 2.48, 2.77, 3.27	Determine static stability characteristics of the command module and launch escape vehicle and investigate the effects of various tower and escape rocket configurations
FS-1	Same as FS-1 above except that particular configurations were selected from among those tested above.	JPL-HWT	5 Mar 1962 to 13 Mar 1962	56.0	5.0, 7.3, 9.0	Determine static stability characteristics of the command module and the launch escape vehicle
FS-7	A 0.02-scale model of the command module with parametrically varied shape. Ten models were used with variations in nose radius, corner radius, blunt end radius, and nose-cone semiangle.	JPL-HWT	14 Mar 1962 to 16 Mar 1962	24.0	5.0, 7.3, 9.0	Determine static stability characteristics of the various command module shapes
FD-2	A 0.055-scale light-weight model of the command module and launch escape vehicle with a detachable tower and escape rocket. The escape rocket had a removable toroidal-shaped tank.	LUPWT (M = 2.6 to 5.0 Leg)	15 Mar 1962 to 19 Mar 1962	44.0	2.4, 3.0 4.0, 4.65	Determine dynamic stability characteristics in pitch of the command module and the launch escape vehicle
FS-2	A 0.105-scale model of the command module and launch escape vehicle with detachable towers and escape motors. Nine combinations of four escape motors and three tower structures were tested.	AUPWT (9 by 7 ft)	19 Mar 1962 to 23 Mar 1962	79.8	1.55, 1.7, 2.0, 2.4	Determine static stability characteristics of the command module and the launch escape vehicle
FS-2	Same as FS-2 above except that particular configurations were selected for testing.	AUPWT (11 by 11 ft)	26 Mar 1962 to 30 Mar 1962	52.6	0.7, 0.9, 1.1, 1.2, 1.35	Determine static stability characteristics of the command module and the launch escape vehicle
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. Tower length and escape rocket nose shape were varied in this test.	JPL-SWT	26 Mar 1962 to 4 Apr 1962	40.0	1.48 to 5.01	Determine static stability characteristics of the command module and launch escape vehicle and investigate the effects of various tower lengths and escape rocket configuration
FS-7	A 0.02-scale model of the command module with parametrically varied shape.	JPL-SWT	26 Mar 1962 to 4 Apr 1962	16.0	1.48 to 5.01	Determine static stability characteristics of the command module
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. A 120-inch tower with gussets at base and escape rocket with forward jettison motor (flush nozzles) was used.	SAL	6 Apr 1962 to 16 Apr 1962	24.4	0.68 to 3.27	Determine static stability characteristics of one additional command module and tower configuration for comparison with JPL and Ames tests
FS-2	A 0.105-scale model of the command module alone.	AUPWT (8 by 7 ft)	9 Apr 1962 to 10 Apr 1962	22.9	2.6, 3.0, 3.4	Determine static stability characteristics of the command module alone

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. A 120-inch tower with gussets at base and escape rocket with forward jettison motor (flush nozzles) was used. Various rocket noses and skirts were also used.	SAL	24 Apr 1962 to 26 Apr 1962	16.2	0.68 to 1.57	Determine static stability characteristics with various size discs located near the rocket skirt
FS-2	A 0.105-scale model of the command module and launch escape vehicle with detachable towers and escape motors.	TWT	20 Apr 1962 to 1 May 1962	52.1	0.70 to 3.50	Determine the logitudinal stability characteristics of the launch escape vehicle with various escape motor configurations
FD-2	A 0.055-scale lightweight model of the command module and launch escape vehicle with a detachable tower and escape rocket.	LTPT	3 May 1962 to 8 May 1962	39.0	0.30 to 1.20	Determine dynamic stability characteristics of command module entry configuration and launch escape vehicle
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. A 120-inch tower with gussets at the base and escape rocket with forward jettison motor (flush nozzles) was used. Jet plumes were simulated by flat plates.	SAL	11 May 1962 to 15 May 1962	3.1	0.70 to 3.24	Tunnel blockage characteristics determined for testing with simulated jet plumes
FS-2	A 0.105-scale model of the command module and launch escape vehicle with detachable towers and escape motors.	AUPWT (11 by 11 ft)	10 May 1962 to 14 May 1962	31.0	0.70 to 1.55	Determine static stability characteristics of command module and launch escape vehicle
FS-2	A 0.105-scale model of the command module and launch escape vehicle with detachable towers and escape motors.	AUPWT (9 by 7 ft)	15 May 1962 to 16 May 1962	22.0	1.55 to 2.40	Determine static stability characteristics of the command module and launch escape vehicle
FD-2	A 0.055-scale lightweight model of the command module and launch escape vehicle with a detachable tower and escape rocket.	LUPWT	28 May 1962 to 1 Jun 1962	40.0	1.5 to 2.8	Determine dynamic stability characteristics of command module entry configuration and launch escape vehicle
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. A 120-inch tower with gussets at the base and escape rocket with forward jettison motor (flush nozzles) was used. Also longitudinal keels were added to the command module.	SAL	6 Jun 1962 to 8 Jun 1962	10.3	0.70 to 3.24	Determine static stability of configuration with the keels added
FS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers and escape motors. Simulated solid jet plumes around model launch escape vehicle.	SAL	14 Jun 1962 to 8 Jul 1962	55.6	0.70 to 3.25	Determine effects of jet plumes on stability of the launch escape vehicle

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FS-2	A 0.105-scale model of the command module and launch escape vehicle with detachable towers and escape motors with keels on side of command module.	AUPWT (8 by 7 ft)	21 Jun 1962 to 27 Jun 1962	38.0	2.6 to 3.4	Determine static stability characteristics of the launch escape vehicle and command module with and without keels
FS-4	A 0.04-scale model of the command module.	AEDC-HS II	2 Jul 1962 to 17 Jul 1962	64.0	18.7	Investigate command module aerodynamic forces and stability characteristics
FD-1	A 0.03-scale model of the command module with the center of gravity on the centerline and another with an offset center of gravity.	JPL-HWT	10 Jul 1962 to 13 Jul 1962	32.0	5.0 to 9.0	Determine dynamic stability characteristics of command module in entry attitude
FD-1	A 0.03-scale model of the command module with the center of gravity on the centerline and a 0.03-scale command module with an offset center of gravity.	JPL-SWT	16 Jul 1962 to 19 Jul 1962	32.0	2.0 to 3.99	Determine dynamic stability characteristics of command module in entry attitude
FS-1	A 0.02-scale model of the command module with several detachable escape tower and motor configurations.	A 2-ft TWT	17 Jul 1962 to 23 Jul 1962	37.0	0.4 to 1.35	Determine the feasibility of testing launch escape vehicle and command module in the transonic range in the A 2-ft TWT
FS-3	A 0.045-scale model of the command module with detachable escape tower and rocket configuration.	AEDC-A	17 Jul 1962 to 26 Jul 1962	42.5	3.0 to 6.0	Determine the static stability of the launch escape vehicle and command module at high supersonic Mach numbers
FS-2	A 0.105-scale model of the command module with several detachable escape tower configurations.	NAAL	17 Jul 1962 to 30 Jul 1962	35.0	0.185, 0.26	Determine the low speed static stability characteristics of the command module and launch escape vehicle
FS-9	A 0.105-scale model of the command module with apex drogue chute heat shield cover removed.	NAAL	27 Jul 1962 to 30 Jul 1962	6.0	0.26	Determine the static stability of the command module just prior to drogue chute deployment
FS-3	A 0.045-scale model of the command module.	AEDC-B	30 Jul 1962 to 1 Aug 1962	25.0	8.0	Determine the static stability of the command module at hypersonic Mach numbers
FS-2	A 0.105-scale model of the command module.	TWT	6 Aug 1962 to 13 Aug 1962	42.3	0.20 to 3.5	Investigate aerodynamic characteristics transonically and supersonically and determine Reynolds number effects subsonically
FS-8	A 0.05-scale model of the command module.	CAL-ST	15 Aug 1962 to 22 Aug 1962	80	15.75	Determine the static aerodynamic characteristics of the command module at hypervelocities
FS-2	A 0.105-scale model of the command module with service module securing washers and with umbilical cord pad on heat shield.	TWT	21 Aug 1962 to 27 Aug 1962	41.8	0.2, 0.4, 0.7, 3.5	Determine the effect of protuberances on the static stability characteristics of the command module

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provision is made for detaching the escape tower, command module, and service module.	AUPWT (11 by 11 ft)	22 Aug 1962 to 24 Aug 1962	31.0	0.7 to 1.4	Determine the static stability and force characteristics of the Saturn I launch and launch abort configurations
FS-2	A 0.105-scale model of the command module with the escape motor mounted on a second balance.	AUPWT(9 by 7 ft)	27 Aug 1962 to 29 Aug 1962	38.0	1.55, 2.0, 2.4	Determine the component loads of the launch escape vehicle while in the presence of each other
FS-3	A 0.045-scale model of the command module.	AEDC-C	31 Aug 1962	9.0	10.0	Determine the static stability of the command module at a hypersonic Mach number
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provision is made for detaching the escape tower, command module, and service module.	AUPWT(by 7 ft)	30 Aug 1962 to 31 Aug 1962	7.5	1.55 to 2.0	Determine the static stability and force characteristics of the Saturn I launch and launch abort configurations
FS-2	A 0.105-scale model of the command module with the escape motor mounted on a second balance.	AUPWT (11 by 11 ft)	30 Aug 1962 to 10 Sep 1962	54.0	0.7 to 1.35	Determine the component loads of the launch escape vehicle while in the presence of each other
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provision is made for detaching the escape tower, command module, and service module.	AUPWT (8 by 7 ft)	5 Sep 1962	6.5	2.5 to 3.5	Determine the static stability and force characteristics of the Saturn I launch and launch abort configurations
FS-2	A 0.105-scale model of the command module with the escape motor mounted on a second balance.	AUPWT (8 by 7 ft)	11 Sep 1962 to 12 Sep 1962	47.0	2.6, 3.0, 3.4	Determine the component loads of the launch escape vehicle while in the presence of each other
FS-3	A 0.045-scale model of the command module.	AEDC-C	24 Sep 1962	10.0	10.0	Determine the static stability of the command module at a hypersonic Mach number
FD-2	A 0.055-scale model of the command module and a revised launch escape vehicle.	LUPWT	24 Sep 1962 to 25 Sep 1962	27.0	1.60 to 2.75	Determine dynamic stability characteristics of the revised launch escape vehicle and investigate the effect of oscillation center location on the command module entry attitude
FS-1	A 0.02-scale model of the command module with various flaps and moldline shapes.	JPL-HWT	27 Sep 1962 to 28 Sep 1962	16.0	7.33	Determine effectiveness of various devices to trim the command module at an angle of attack of 147 degrees
FS-1	Two 0.02-scale models of the command module sting mounted with angles of 20 and 80 degrees relative to the airflow.	A 2-ft TWT	1 Oct 1962 to 18 Oct 1962	65.0	0.7 to 1.35	Determine effectiveness of various devices for eliminating the trim point between angles of attack of 50 and 80 degrees

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provisions were made for removing the launch escape vehicle washer, detaching the escape tower, command module, and service module.	AEDC-B	1 Oct 1962 to 2 Oct 1962	11.0	8.0	Determine the static stability and force characteristics of the Saturn I launch and launch-abort configurations
FSL-1	Same as above	AEDC-A	5 Oct 1962 to 9 Oct 1962	16.0	3.5 to 6.0	Determine the static stability and force characteristics of the Saturn I launch and launch-abort configurations
FD-2	A 0.055-scale model of the command module with detachable escape tower.	LTPT	23 Oct 1962 to 25 Oct 1962	20.0	0.30 to 1.20	Determine dynamic stability characteristics of revised launch escape vehicle and investigate the effect of oscillation center location on the command module entry configuration
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provision was made for detaching the escape tower, command module, and service module.	TWT	1 Nov 1962 to 13 Nov 1962	45.0	0.40 to 3.5	Determine the static stability and force characteristics of the Saturn I launch and launch-abort configurations
FSC-1	A 0.10-scale model of the command module and drogue chute.	NAAL	5 Nov 1962 to 3 Dec 1962	83.4	0.104 to 0.168	Determine drogue parachutes with favorable stability characteristics
FS-1	A 0.02-scale model of the command module. Four models sting mounted at angles of 0, 40, 80, and 140 degrees relative to the airflow.	JPL-SWT	7 Nov 1962 to 13 Nov 1962	32.0	0.7 to 5.01	Same as above
FD-2	A 0.055-scale model of the command module with detachable escape tower.	LUPWT	16 Nov 1962	10.0	3.00 to 4.65	Determine the dynamic stability characteristics of the revised launch escape vehicle
SD-1	A 0.08-scale dynamically similar model of the Apollo-Saturn launch configuration with scaled mass and stiffness distribution. Aluminum tube core with styrofoam fairing and lead ballast.	L 16-ft TDT	17 Nov 1962 to 7 Dec 1962	240.0	0.6 to 1.2	Determine response of launch vehicle to transonic buffeting and measure effect of aerodynamic damping on lateral bending of launch vehicle
FS-2	A 0.105-scale model of the command module with various flow separator strakes.	TWT	19 Nov 1962 to 29 Nov 1962	24.0	0.4, 0.7	Determine effectiveness of various keels and spoilers for eliminating the command module apex-forward trim point between angles of attack of 40 and 80 degrees

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FD-3	A 0.045-scale model of the command module and a 0.059-scale model of the launch escape vehicle.	AEDC-A	26 Nov 1962 to 30 Nov 1962	27.0	1.5 to 6.0	Determine dynamic stability characteristics of launch escape and command module configurations with the oscillation center on the design center of gravity
FSL-1	A 0.02-scale model of the complete launch (L) configuration with the Saturn I launch vehicle. Provisions for detaching the escape tower, the command module, and service module are provided.	NACAL	27 Nov 1962 to 28 Nov 1962	20.0	0.31	Determine the static stability and force characteristics of the Saturn I launch and launch-abort configurations
FDC-1	A 0.10-scale model of the command module with various drogue parachutes.	NAAL	27 Nov 1962 to 29 Nov 1962	35.5	0.104 to 0.168	Investigate the dynamic stability characteristics of the command module and drogue chute combinations
FDC-1	A 0.10 dynamically scaled command module with ±180 degrees of freedom in pitch and ±10 degrees of freedom in roll and yaw. Various drogue chutes were used in conjunction with this model.	L 16-ft TDT	10 Dec 1962 to 14 Dec 1962	54.5	0.15 to 1.12	Investigate the dynamic stability characteristics of the command module and drogue chute combinations
FD-3	A 0.045-scale model of the command module.	AEDC-C	11 Dec 1962 to 12 Dec 1962	24.0	10.0	Determine dynamic stability characteristics of the command module entry configuration with the oscillation center on the design center of gravity
FD-3	A 0.059-scale model of the launch escape vehicle.	AEDC-A	4 Jan 1963 to 6 Jan 1963	15.0	1.5 to 4.0	Determine dynamic stability characteristics of the launch escape vehicle with disc on and oscillation center on design center of gravity
FS-2	A 0.105-scale model of the launch escape vehicle and command module with strakes.	AUPWT (11 by 11 ft)	7 Jan 1963 to 18 Jan 1963	143.0	0.5 to 1.35	Determine static stability characteristics of the launch escape vehicle and evaluate the aerodynamic strakes attached to the command module
FS-2	Same as above	AUPWT (8 by 7 ft)	21 Jan 1963 to 24 Jan 1963	58.0	3.0 and 3.4	Same as above
FS-2	Same as above	AUPWT (9 by 7 ft)	25 Jan 1963 to 29 Jan 1963	51.0	1.55 to 2.4	Same as above
FS-3	A 0.045-scale model of the command module and the launch escape vehicle.	AEDC-A	28 Jan 1963 to 14 Feb 1963 and 8 Mar 1963	87	4.0 to 6.0	Determine static stability in pitch and yaw of of the command module and launch escape vehicle with command module mounted strakes

Table 1. Summary of Force Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
FS-3	A 0.045-scale model of the command module with strakes.	AEDC-C	21 Feb 1963 to 23 Feb 1963	17.2	10.0	Determine static stability in pitch and yaw of the command module with strakes
FDC-1	A 0.010-scale model of the command module with three chutes.	NAAL	21 Jan 1963 to 1 Feb 1963	59.9	0.08 to 0.23	Forced oscillation tests to investigate the dynamic stability characteristics of the command module and drogue chute combination
FSJ-1	0.085-scale model of the launch escape vehicle with a H_2O_2 exhaust system.	L 16 ft	4 Mar 1963 to 19 Mar 1963	88.0	0.7 to 1.3	To evaluate jet effects of the escape motor on static stability and study launch escape vehicle-service module separation, jet on and off
FD-5	0.050-scale model of the command module 0.059-scale model of launch escape vehicle.	AEDC-A	18 Apr 1963 to 25 Apr 1963	38.0	1.5 to 6.0	Determine dynamic stability characteristics of launch escape and command module configurations (free-oscillation technique) with oscillation center on design center of gravity and alternate locations, strakes on and off

Table 2. Summary of Pressure Tests Actually Conducted

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
PS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers representing full-scale lengths of 85 and 120 inches. One escape rocket configuration with a flared skirt and without the toroidal shaped tanks was used. Forty-eight pressure taps were incorporated on the surface of the command module.	JPL-SWT	12 Mar 1962 to 19 Mar 1962	40.0	1.5, 2.0, 3.0, 4.0, 5.0	Determine pressure distributions on the command module with and without the escape tower
PS-1	A 0.02-scale model of the command module and launch escape vehicle with detachable towers. Three command modules were sting mounted at angles of 28, 90, and 152 degrees (angle between sting and model centerline). They also had removable towers and rocket motors.	JPL-HWT	2 Apr 1962 to 13 Apr 1962	80.0	5.06 to 9.08	Determine pressure distributions on the command module and launch escape vehicle
PS-6	A 0.01875-scale model of the command module instrumented with miniature pressure transducers.	NAA-12-in. ST	2 May 1962 to 12 Jul 1962	160.0	15.5 to 18.3	Determine pressure distribution on the command module at high Mach numbers
PS-4	A 0.04-scale model of the command module instrumented with miniature pressure transducers for obtaining pressure distributions.	AEDC-HS II	15 Jun 1962 to 30 Jun 1962	48.0	19.5	Determine pressure distribution on the command module for determining the aerodynamics loads during entry
PSTL-1	A 0.055-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. Provision is also made for detaching the escape tower.	TWT	18 Jun 1962 to 9 Jul 1962	107.8	0.7 to 3.5	Determine steady-state and transient pressures on the launch configuration
PS-3	Three 0.045-scale models of the command module sting mounted with angles of 30, 90, and 150 degrees relative to air flow. Also one detachable tower and rocket configuration.	AEDC-A	30 Jul 1962 to 7 Aug 1962	58.0	1.5 to 5.0	Determine static pressure distributions on the command module with and without the launch escape system
PS-3	Three 0.045-scale models of the command module sting mounted with angles of 30, 90, and 150 degrees relative to air flow. Also one detachable tower and rocket configuration.	AEDC-B	7 Aug 1962 to 15 Aug 1962	22.0	8.0	Determine pressure distribution on the command module with and without the launch escape system and on the command module with the service module
PSTL-1	A 0.055-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. Provision is also made for detaching the escape tower.	A 14-ft TWT	6 Aug 1962 to 29 Aug 1962	144.0	0.5 to 1.11	Study unsteady aerodynamic pressures incident to the spacecraft and adaptor during normal boost to atmospheric exit

Table 2. Summary of Pressure Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
PS-1	Three 0.02-scale models of the command modules sting mounted at angles of 28, 90, and 152 degrees relative to the air flow.	A 2-ft TWT	20 Aug 1962 to 24 Aug 1962	40.0	0.4 to 1.34	Determine pressure distribution on the command module
PS-3	Three 0.045-scale models of the command module sting mounted at angles of 30, 90, and 120 degrees relative to the air flow. Also one command module-service module configuration mounted at 30 degrees relative to the air flow.	AEDC-C	6 Sep 1962	8.0	10.0	Determine pressure distribution on the command module
PSTL-1	A 0.55-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. Provision is made for detaching the escape tower.	AUPWT (11 by 11 ft)	10 Sep 1962 to 14 Sep 1962	40.0	0.7 to 1.35	Obtain steady-state pressure distribution on the spacecraft, adaptor, and forward portion of the Saturn C-1 during boost and atmospheric exit
PSTL-1	Same as above	AUPWT (8 by 7 ft)	14 Sep 1962 to 18 Sep 1962	24.0	2.5 to 3.5	Same as above
PS-3	Three 0.045-scale models of the command module sting mounted at angles of 30, 90, and 120 degrees relative to the air flow. Also one command module-service module configuration mounted at 30 degrees relative to the air flow.	AEDC-C	21 Sep 1962 to 22 Sep 1962	16.0	10.0	Determine pressure distributions on the command module
PSTL-1	A 0.55-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. Provision is made for detaching the escape tower.	AUPWT (9 by 7 ft)	1 Oct 1962 to 9 Oct 1962	70.0	1.25 to 2.5	Obtain steady-state and transient pressure distributions on the spacecraft, adaptor, and forward portion of the Saturn I during boost and atmospheric exit
PS-3	Two 0.045-scale models of the command module with two detachable escape rockets and one escape tower.	TWT	8 Oct 1962 to 20 Oct 1962	75.3	0.40 to 1.36	Determine basic loads on the launch escape vehicle between angles of attack of 0 and 140 degrees
PS-5	A 0.050-scale, thick skin brass model of the command module	CAL-ST	17 Oct 1963 to 25 Oct 1963	46.0	12.0 to 17.3	To obtain pressure distributions on the command module for correlation with heat transfer tests
PS-3	Same as others	AEDC-C	1 Dec 1962	8.0	10.0	Determine pressure distribution over the command module
PS-9	A 7.4 inch-diameter hemisphere cylinder instrumented with 85 pressure taps	AEDC-C	3 Jan 1963	4.0	10.0	Obtain pressure distribution on a hemisphere cylinder

Table 2. Summary of Pressure Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
PS-1	A 0.020-scale command module instrumented with 64 pressure taps	AEDC-C	4 Jan 1963	4.0	10.0	Obtain pressure distribution on a command module
PS-3	Three 0.045-scale models of the command module with strakes and one detachable escape rocket and escape tower	AEDC-A	1 Apr 1963 to	49.0	1.5 to 3.0	Same as above
PS-3	Three 0.045-scale models of the command module with strakes	AEDC-C	10 Apr 1963 to 13 Apr 1963	39.0	10.0	Same as above

Table 3. Summary of Heat Transfer Tests Actually Conducted

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
H-1	A 0.02-scale thin-skin (0.030 inch) model of the command module. No. 36 wire iron-constantan thermocouples were spot welded to the inside surface. Skin of 310 stainless steel was used for low specific heat and low conductivity. Fifteen static pressure taps were made on the service module of launch configuration. Forty-two thermocouples were used on command and service module of launch configuration and forty-four thermocouples on command module of entry configuration. Entry configurations using the module alone and the module with transition grit were tested. Launch configurations consisting of the command and service module and the entire launch escape vehicle were tested.	JPL-HWT	16 Apr 1962 to 26 Apr 1962	68.0	6.0 to 9.0	Determine heating rate distributions over the model surface for launch and entry configurations and obtain pressure distribution on the service module for correlation with heat transfer data
H-6	A 0.01875-scale model of the command module instrumented with thin-film platinum resistance heat transfer gages.	NAA 12-inch ST	2 May 1962 to 12 Jul 1962	160.0	15.5 to 18.3	Determine heat transfer distribution over the command module
H-2	A 0.045-scale thin-skin (0.040 inch) model of the command module. No. 30 gage iron constantan thermocouple wire was spot welded to the inside surface of the model skin. Skin of 310 stainless steel was used for low specific heat and low conductivity. Entry configurations using the command module alone and the command module with transition strip were tested. Launch configurations consisting of the command and service module and the entire launch escape vehicle were tested.	AEDC-B	14 Jun 1962 to 16 Jun 1962	40.0	8.0	Determine heat transfer distributions over the model surface for launch and entry configurations through a simulated flight regime
H-2	Same as above	AEDC-C	19 Jun 1962 and 10 Jul 1962 to 12 Jul 1962	30.0	10.0	Determine heat transfer distributions over the model surface for launch and entry configurations through a simulated flight regime
H-4	A 0.050-scale thick skin, brass model of the command module	CAL-ST	17 Oct 1962 to 25 Oct 1962	64.0	6, 13 to 17.3	Obtain heating rates at a number of locations on the command module
H-7	A 0.040-scale stainless steel model of the command module with thick skin face to accommodate calorimeters and pressure orifices	AEDC-F	12 Nov 1962 to 19 Nov 1962 and 29 Nov 1962 to 30 Nov 1962	56.0	18.95 to 20.20	Obtain heat transfer rates and correlating pressure data on the command module in the entry position

Table 3. Summary of Heat Transfer Tests Actually Conducted (Cont)

Model	Model Description	Test Facility	Test Period	Test Hours	Mach No. Range	Test Objective
H-2	A 0.045-scale thin-skin (0.040 inches) model of the command module. No. 30 gage iron constantan thermocouple wire is spot welded to the inside surface of the model skin. Skin is of 310 stainless steel for low specific heat and low conductivity.	AEDC-C	28 Nov 1962	8.0	10.0	Obtain heat transfer distributions over the command module entry configuration
HL-1, HL-1B	A 0.045-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. This model had a detachable escape tower.	AEDC-C	29 Nov 1962 to 30 Nov 1962	24.0	10.0	Obtain heat transfer distributions on the launch configuration
H-9	A 7.4-inch-diameter hemisphere cylinder instrumented with 85 thermocouples.	AEDC-C	3 Jan 1963	4	10.0	Obtain heat transfer distributions of the hemisphere cylinder for study of cutsphere theory
H-1	A 0.02-scale model of the command model instrumented with 64 thermocouples	AEDC-C	4 Jan 1963	4	10.0	Obtain heat transfer distributions over the command module for study of cutsphere theory
HL-1, HL-1B	0.045-scale thin-skin heat transfer models of the command module.	LUPWT	16 Jan 1963 to 22 Jan 1963	80.0	2.5 to 3.71	To obtain heat transfer distributions on launch and entry configuration with strakes of the Apollo vehicle through a simulated flight regime
H-2	Same as above	LUPWT	23 Jan 1963 to 29 Jan 1963	80.0	2.5 to 3.71	Same as above
HL-1B	A 0.045-scale, thin-skinned model of the launch escape vehicle with strakes on command module instrumented with 98 thermocouples.	AEDC-C	2 Apr 1963	8.0	10.0	Obtain heat transfer distributions on the launch escape vehicle with strakes on the command module
H-2	A 0.045-scale, thin-skinned model of the command module with strakes and the command module and service module instrumented with 98 thermocouples.	AEDC-C	3 Apr 1963 to 4 Apr 1963	22.0	10.0	Obtain heat transfer distributions on the command module with strakes and the command module and service module

II. TEST OBJECTIVES

The basic objectives of the wind tunnel test program are to provide, in the shortest possible time, sufficiently accurate and inclusive data to evaluate factors that affect the final design of the spacecraft and to provide information to prove the validity of the configuration selected for final development.

In general, the test program used relatively simple small-scale models for the initial evaluation of gross aerodynamic characteristics; the program then progressed to more detailed large-scale models as the final configuration became determined. The various tests and the models used in the wind tunnel test program are presented in the following paragraphs.

STATIC FORCE TESTS

The initial tests to determine basic static stability and force characteristics of the entry, launch and launch-abort configurations were completed throughout the flight regimes.

Subsequent investigations were made at subsonic, transonic, supersonic, and hypersonic Mach numbers to evaluate the effect on the aerodynamic characteristics of the command module and launch escape system under the following conditions:

1. Addition of aerodynamic strakes to the command module

2. Launch escape system rocket motor operating using hydrogen peroxide as a propellant

3. Drogue chute configurations attached to the command module

Static stability and force characteristics of the Saturn I with Apollo payload and booster alone have been determined at Mach numbers 0.3 to 8.0.

Free-flight characteristics of the command module and the launch escape vehicle, including static and dynamic stability data, are being investigated in ballistic range facilities.

DYNAMIC FORCE TESTS

Forced and free-oscillation dynamic tests were conducted to determine the dynamic stability characteristics of command module and launch escape vehicle configurations with and without strakes.

Dynamic stability data were obtained from forced oscillation tests of the command module in the angle-of-attack range from -10 to +190 degrees at Mach numbers 1.5 to 10.0 and on the launch escape vehicle for the angle-of-attack range from -5 to +25 degrees at Mach numbers 1.5 to 6.0. Subsonic and transonic dynamic stability characteristics of the command module and launch escape vehicle were also obtained.

High-amplitude free-oscillation tests to obtain dynamic stability characteristics on entry and launch escape vehicle configurations were made at Mach numbers 1.5 to 6.0 with oscillating amplitudes of ± 20 degrees about the trim points. Additional tests will extend this investigation into the transonic region.

Tests to determine tumbling dynamic stability characteristics of a 360-degree rotational model of the command module will be made at Mach numbers 0.2 to 0.9.

Dynamic stability characteristics of the command module with the drogue chute were obtained with the model at normal trim, apex-forward trim, and tumbling attitudes.

STRUCTURAL DYNAMIC TESTS

Tests at transonic Mach numbers were made on the Apollo/Saturn I launch configuration to obtain buffeting loads and measurements of aerodynamic damping.

STATIC PRESSURE TESTS

Initial structural design loads were obtained on the command module and the launch escape vehicle from pressure measurements made at Mach numbers 1.5 to 10.0. Pressure measurements were also obtained on the command module at Mach number 19.5. Additional air load data were obtained on the launch escape vehicle and command module at transonic Mach numbers.

Pressure data with some real gas effects were recorded in the Mach number 15 region.

STATIC AND TRANSIENT PRESSURE TESTS

Static and transient pressure measurements were made at Mach numbers 0.7 to 3.5 to study unsteady aerodynamic pressures and to determine aerodynamic loads on the spacecraft and adapter during normal boost. Additional tests are scheduled.

HEAT TRANSFER TESTS

The heat transfer models have been designed to obtain heat transfer distributions over launch and entry configurations of the Apollo vehicle. Initial stages of the program consisted of investigating distribution effects at Mach numbers 6, 7, and 9. Additional tests were run to determine effects of configuration changes on Reynolds number heat transfer distributions. Distributions on entry configurations at Mach numbers 13 to 20 were obtained in shock and impulse tunnels.

Tests are currently scheduled on the launch and entry configurations at Mach numbers 6 to 17. These tests will provide information on the effect of attached and separated flow and on protuberances and holes.

Tests to obtain real gas effects on the entry face heating rates will be conducted in ballistic ranges and plasma jet tunnels. Plasma jet facilities, which are in the development stage, are currently being evaluated for selecting a suitable tunnel.

III. TEST FACILITIES

The Apollo wind tunnel test program has taken into account the wide range of flight conditions that the spacecraft will encounter from launch to entry and recovery. To obtain data applicable to these conditions, many types of facilities will be used. These facilities are listed with a brief description of their characteristics. The capability of these facilities to simulate the Apollo boost and entry trajectories is graphically presented in Figures 1 and 2. Estimated and actual test facility hours for calendar years 1962, 1963, 1964, and 1965 are presented in Tables 4 and 5.

Continuous Tunnels

North American Aerodynamics Laboratory 7.75- by 11-Foot Low-Speed Wind Tunnel. A Mach number of approximately 0.2 can be obtained at a Reynolds number of approximately 1.44×10^6 per foot.

North American Columbus Division Aerodynamics Laboratory 7- by 10-Foot Subsonic Wind Tunnel. A Mach number range from 0.05 to 0.39 can be obtained at a Reynolds number of approximately 2.7×10^6 per foot.

Langley 20-Foot Free-Spinning Tunnel. A velocity of 0 to 66 mph can be obtained at a Reynolds number range from 0 to 0.62×10^6 per foot.

Langley 12-Foot Low-Speed Tunnel. A velocity of 40 to 50 mph is obtainable in this tunnel.

Langley 8-Foot Transonic Pressure Tunnel. Mach numbers from 0 to 1.2 are available over a Reynolds number range from 1 to 4×10^6 per foot.

Langley Unitary Plan Wind Tunnel. Two 4- by 4-foot test sections are used, one covering Mach numbers from 1.5 to 2.8 and the other covering Mach numbers from 2.6 to 5 at Reynolds numbers up to 10×10^6 per foot.

Langley 16-Foot Transonic Dynamics Tunnel. Mach numbers from 0.3 to 1.2 can be obtained. Reynolds number varies from 0.04 to 9.0×10^6 per foot. The tunnel may be operated using either air or freon as the test media.

Langley 16-Foot Transonic Wind Tunnel. Mach numbers from 0.2 to 1.3 can be obtained. Reynolds number varies from 1.2×10^6 to 4.15×10^6 per foot.

Jet Propulsion Laboratory 20-Inch Supersonic Wind Tunnel. Mach numbers from 1.3 through 5 can be achieved, and Reynolds numbers between 0.04 and 6×10^6 per foot are obtained.

Jet Propulsion Laboratory 21-Inch Hypersonic Wind Tunnel. This facility covers the Mach number range between 5 and 9.5 at Reynolds numbers from 0.25×10^6 to 3.6×10^6 per foot.

Cornell Aeronautical Laboratory 8-Foot Transonic Wind Tunnel. This variable density wind tunnel operates at total pressures of from 1/6 atmospheres (350 psf) to 2-1/2 atmospheres (5290 psf). The Mach number range is from approximately 0 to 1.4 with Reynolds number per foot ranging from 1×10^6 to 7×10^6.

Arnold Engineering Development Center von Karman Facility 40-Inch Tunnel A. Mach numbers from 1.5 to 6 can be obtained and a Reynolds number range from 0.3×10^6 to 9×10^6 per foot can be covered.

Arnold Engineering Development Center von Karman Facility 50-Inch Tunnel B. This tunnel operates at Mach number 8 over a Reynolds number range from 0.25×10^6 to 3.3×10^6 per foot.

Arnold Engineering Development Center von Karman Facility 50-Inch Tunnel C. A Mach number of 10 is obtained with a Reynolds number range from 0.29×10^6 to 2.5×10^6 per foot.

Ames Unitary Plan Wind Tunnel. This facility has three test sections. The 11-foot test section covers the range from Mach number 0.5 to 1.4 at Reynolds numbers up to 8.5×10^6 per foot. The 9- by 7-foot test section operates between Mach numbers 1.5 and 2.6 at Reynolds numbers up to approximately 6×10^6. The 8- by 7-foot test section covers a Mach number range from 2.4 to 3.5 at Reynolds numbers up to the order of 3 to 5×10^6 per foot.

Ames 14-Foot Transonic Wind Tunnel. This tunnel operates at Mach numbers from 0.6 to 1.2 at Reynolds numbers from 2.8×10^6 to 4.2×10^6 per foot.

Ames 2-Foot Transonic Wind Tunnel. This tunnel operates at Mach numbers from 0 to 1.4 at Reynolds numbers from 2×10^6 to 8.4×10^6 per foot.

Ames 6-Inch Arc Jet Tunnel. This tunnel operates at Mach numbers 10 and 16 with a stagnation enthalpy of 900 Btu/lb.

Ames 12-Foot Pressure Wind Tunnel. This tunnel operates at Mach numbers 0 to 1.0 at Reynolds numbers from 0 to 9.2×10^6.

Intermittent Tunnels

North American Aviation Supersonic Aerophysics Laboratory. Mach numbers of 0.7 and from 1.56 through 3.75 and Reynolds numbers between 3.88×10^6 and 2.26×10^6 per foot are obtained in this tunnel.

North American Aviation 7- by 7-Foot Trisonic Wind Tunnel. Mach numbers from 0.2 to 3.5 are available, and Reynolds numbers from 5×10^6 to 14×10^6 per foot can be obtained.

Fluidyne 20-Inch Mach Number 14 Hypersonic Tunnel. Reynolds numbers from 0.28×10^6 to 0.6×10^6 per foot can be obtained.

Impulse Tunnels

Arnold Engineering Development Center von Karman Facility 50-Inch Hot-Shot II. This tunnel currently operates at Mach numbers from 16 to 21 are obtained with nitrogen as a test medium. Stagnation pressure is normally 1000 atmospheres.

Arnold Engineering Development Center von Karman Facility 100-Inch Tunnel F. Mach numbers from 16 to 22 can be obtained with a Reynolds number range from 5×10^4 to 8×10^5 per foot.

Avco 10-Foot Shock Tunnel. Mach numbers from 5 to 35 can be obtained with a Reynolds number range from 10^4 to 10^7 per foot.

Avco 20-Inch Shock Tunnel. Mach numbers from 8 to 28 can be obtained with a Reynolds number range from 10^3 to 1.2×10^5 per foot.

Avco 1-1/2-Inch Shock Tube. Mach numbers from 1.8 to 2.6 can be obtained with a Reynolds number range from 5×10^3 to 10^8 per foot.

Cornell Aeronautical Laboratory 24- and 48-Inch Shock Tunnels. Mach numbers from 5 to 18 can be obtained with a Reynolds number range from 0.03×10^6 to 10×10^6 per foot at the lower Mach number.

Cornell Aeronautical Laboratory 8-Foot Shock Tunnel. Mach numbers from 10 to 30 are available, and a Reynolds number range from 2×10^2 to 5×10^5 per foot can be obtained.

North American Aviation 12-Inch Shock Tunnel. Mach numbers from 7 to 22 can be obtained with a Reynolds number range from 0.0001×10^6 to 3×10^6 per foot.

Free-Flight Facilities

Ames Prototype Hypersonic Free-Flight Facility. Velocities up to 40,000 fps are obtained by firing models approximately 0.45 inches in diameter into a hypersonic shock tunnel.

Ballistic Research Laboratory Transonic Aerodynamics Range. Mach numbers from 0.5 to 6.5 are obtained with Reynolds numbers from 4.0×10^6 to 44.0×10^6.

Canadian Armament Research and Development Establishment (CARDE) Range No. 5. Velocities from the Transonic Range to approximately 15,000 ft/sec are obtained with Reynolds numbers to 4×10^7 based on model diameter. Models of 5 inches diameter are launched under these conditions.

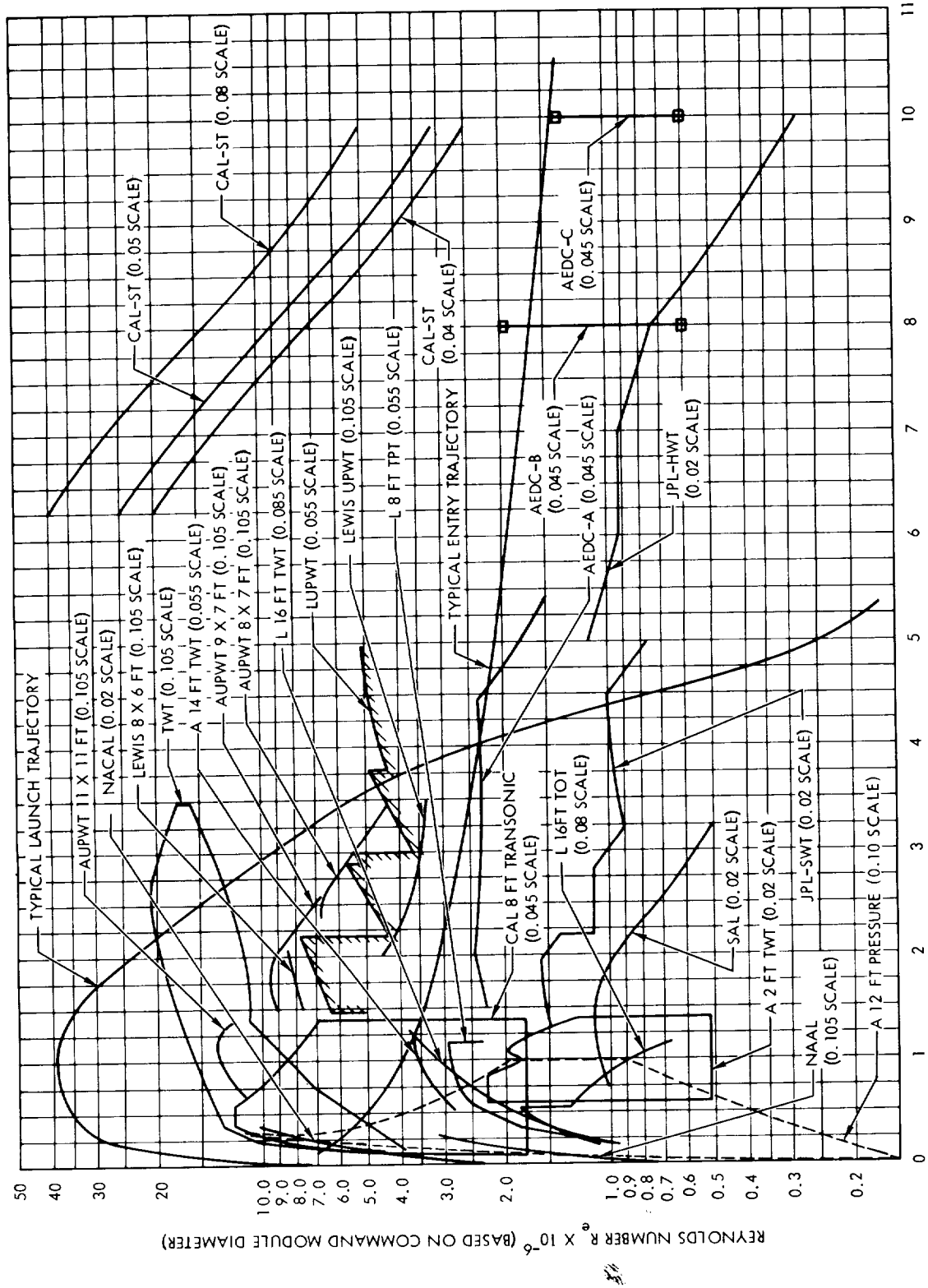

Figure 1. Test Facilities Capabilities (Reynolds Number Versus Mach Number)

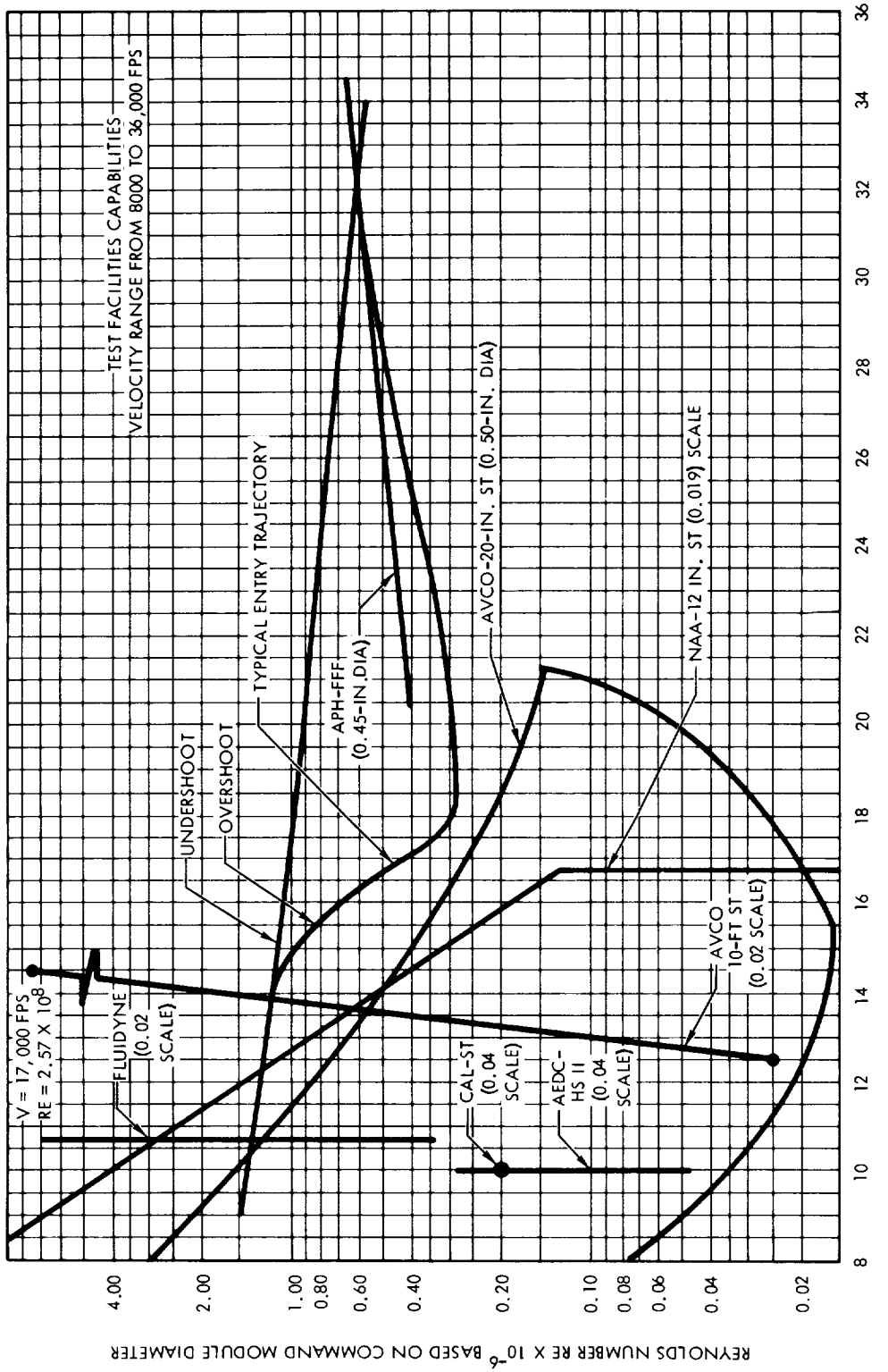

Figure 2. Test Facilities Capabilities (Reynolds Number Versus Velocity)

Table 4. Test Facilities and Time Used in 1962

Designation	Tunnel	Test Section Size	Type of Tunnel	Calendar 1962 Hours Used				Models
				Force	Press.	Heat	Subtotal	
AUPWT	Ames Unitary Plan Wind Tunnel	3 test sections 11 by 11 ft 9 by 7 ft 8 by 7 ft	Continuous M = 0.7 to 1.4 M = 1.5 to 2.6 M = 2.4 to 3.5	168.6 147.3 114.4	40.0 70.0 24.0		208.6 217.3 138.4	FS-2, FSL-1 PSTL-1
A 14-Ft TWT	Ames 14-Ft Transonic Wind Tunnel	13.5 by 13.5 ft	Continuous M = 0.6 to 1.2		144.0		144.0	PSTL-1
A 2-Ft TWT	Ames 2-Ft Transonic Wind Tunnel	2 by 2 ft	Continuous M = 0 to 1.4	102.0	40.0		142.0	FS-1, PS-1
LUPWT	Langley Unitary Plan Wind Tunnel	2 test sections, each 4 by 4 ft	Continuous M = 1.5 to 2.8 M = 2.6 to 5	67.0 54.0			67.0 54.0	FD-2
LTPT	Langley Transonic Pressure Tunnel	8 by 8 ft	Continuous M = 0 to 1.2	59.0			59.0	FD-2
L 12-Ft LST	Langley 12-Ft Low-Speed Tunnel	12 ft octagonal	Continuous Low Speed, to V = 40 to 50 mph					FD-4
L 16-Ft TDT	Langley 16-Ft Transonic Dynamics Tunnel	16 by 16 ft	Continuous M = 0.3 to 1.2	294.5			294.5	SD-1, FDC-1
L 16-Ft TWT	Langley 16-Ft Transonic Wind Tunnel	16 by 16 ft	Continuous M = 0.2 to 1.3					FSJ-1
JPL-SWT	Jet Propulsion Laboratory Supersonic Tunnel	18 by 20 in.	Continuous M = 1.3 to 5	120.0	40.0		160.0	FS-1, FS-7, FD-1, PS-1
JPL-HWT	Jet Propulsion Laboratory 21-inch Hypersonic Tunnel	21 by 15 in. to 28 in.	Continuous M = 5 to 9.5	128.0	80.0	68.0	276.0	FS-1, FS-7, FD-1, PS-1, H-1
AEDC-A	Arnold Engr. Dev. Center-von Karman Facility A	40 by 40 in.	Continuous M = 1.5 to 6	85.5	58.0		143.5	FS-3, FSL-1, PS-3, FD-3

Table 4. Test Facilities and Time Used in 1962 (Cont)

Designation	Tunnel	Test Section Size	Type of Tunnel	Calendar 1962 Hours Used				Models
				Force	Press.	Heat	Subtotal	
AEDC-B	Arnold Engr. Dev. Center-von Karman Facility B	50 in. diameter	Continuous M = 8	36.0	22.0	40.0	98.0	FS-3, FSL-1, PS-3, H-2
AEDC-C	Arnold Engr. Dev. Center-von Karman Facility C	50 in. diameter	Continuous M = 10	43.0	32.0	62.0	137.0	FS-3, FD-3, PS-3, H-2, HL-1, HL-1B
AEDC-HS II	Arnold Engr. Dev. Center-von Karman Facility-Hot Shot II	50 in. diameter	Arc-driven M = 16 to 21	64.0	48.0		112.0	FS-4, PS-4
NAAL	North American Aerodynamics Laboratory	7.75 by 11 ft	Continuous Low Speed to M = 0.23	159.9			159.9	FS-2, FS-9, FSC-1, FDC-1
TWT	North American Trisonic Wind Tunnel	7 by 7 ft	Intermittent M = 0.2 to 3.5	205.2	183.1		388.3	FS-2, FSL-1, PS-3, PSTL-1
SAL	North American Supersonic Aero-Physics Lab	16 by 16 in.	Intermittent M = 0.7, 1.56 to 3.75	163.7			163.7	FS-1
NACAL	North American Columbus Division Aerodynamics Lab	7 by 10 ft	Continuous Low Speed to M = 0.39	20.0			20.0	FSL-1
NAA-12" ST	North American Aviation 12-inch Shock Tunnel	12 in. diameter	Shock-driven M = 7 to 22		160.0	160.0	320.0	PS-6, H-6
CAL-ST	Cornell Aeronautical Laboratory Shock Tunnel	24 to 48 in. diameter	Shock-driven M = 6 to 17	80.0	32.0	32.0	144.0	FS-8, PS-5, H-4
AEDC-F	Arnold Engr. Dev. Center-von Karman Facility F	100 in. diameter	Arc-driven M = 16 to 22			64.0	64.0	H-7
Totals				2272.1	973.1	266.0	3511.2	

Table 5. Test Facilities and Time Requirements for 1963 and 1964

Designation	Tunnel	Test Section Size	Type of Tunnel	Estimated Hours: Last Report (1963, 1964, 1965) Force	Press.	Heat	Subtotal	Estimated Hours: Presently (1963, 1964) Force	Press.	Heat	Subtotal	Hours Used: 1 Jan 1963 to 30 May 1963 Force	Press.	Heat	Subtotal	Models
AUPWT	Ames Unitary Plan Wind Tunnel	3 test sections 11 by 11 ft 9 by 7 ft 8 by 7 ft	Continuous M = 0.7 to 1.4 M = 1.5 to 2.6 M = 2.4 to 3.5	190.0 140.0 140.0	60.0 40.0 20.0		250.0 180.0 160.0	310.0 200.0 200.0	120.0		430.0 200.0 200.0	143.0 51.0 58.0			143.0 51.0 58.0	FS-2, FD-5 FS-2 FS-2
A 14-ft TWT	Ames 14-ft Transonic Wind Tunnel	13.5 by 13.5 ft	Continuous M = 0.6 to 1.2		80.0		80.0									
AEDC-A	Arnold Engr. Dev. Center-von Karman Facility A	40 by 40 in.	Continuous M = 1.5 to 6.0	300.0	40.0		340.0	480.0	60.0		540.0	140.0	49.0		189.0	FS-3, FSJ-3 FD-5, PS-3 FD-3
AEDC-B	Arnold Engr. Dev. Center-von Karman Facility B	50 in. diameter	Continuous M = 8.0	60.0	20.0		80.0	40.0			40.0					FS-3
AEDC-C	Arnold Engr. Dev. Center-von Karman Facility C	50 in. diameter	Continuous M = 10.0	100.0	20.0	100.0	220.0	100.0	20.0	160.0	280.0	17.2	47.0	38.0	102.2	FS-3, PS-3 H-1, H-2 H-9, HL-1, HL-1B FD-5, PS-1, PS-9
NAAL	North American Aerodynamics Laboratory	7.75 by 11 ft	Continuous, low speed to M = 0.23	60.0			60.0	40.0			40.0	59.9			59.9	FDC-1
TWT	North American Trisonic Wind Tunnel	7 by 7 ft	Intermittent M = 0.2 to 3.5	120.0			120.0	120.0	40.0		160.0					FS-2, PSTL-2
CAL-ST 4	Cornell Aeronautical Laboratory Shock Tunnel	24 to 48 in. diameter	Shock driven M = 6 to 17	40.0		80.0	120.0		30.0	190.0	220.0					PS-5, H-4
CAL-ST 6 ft	Cornell Aeronautical Laboratory Shock Tunnel	6 ft diameter	Shock driven M = 10 to 30		40.0	80.0	120.0		40.0	80.0	120.0					PS-7, H-11
CAL-ST 8 ft	Cornell Aeronautical Laboratory Transonic Wind Tunnel	8 ft diameter	Continuous M = 0 to 1.4	80.0			80.0									
LUPWT	Langley Unitary Plan Wind Tunnel	Two 4- by 4-ft test sections	Continuous M = 1.5 to 2.8 M = 2.6 to 5	100.0		80.0	180.0	40.0		80.0	120.0			160.0	160.0	FD-2, H-2 HL-1, HL-1B
LTWT	Langley 16-ft Transonic Wind Tunnel	16 by 16 ft	Continuous M = 0.2 to 1.3	120.0			120.0	160.0			160.0	88.0			88.0	FSJ-1
LTPT	Langley Transonic Pressure Tunnel	8 by 8 ft	Continuous M = 0 to 1.2	40.0	80.0		120.0	20.0	80.0		100.0					FD-2, PS-3
AVCO 10-ft ST	Avco 10-ft Shock Tunnel	10 ft diameter	Intermittent M = 5 to 35			80.0	80.0									
AVCO 20-in. ST	Avco 20-in. Shock Tunnel	20 in. diameter	Shock driven M = 8 to 28			80.0	80.0									
CARDE	Range No. 5	7 in. diameter	Velocity = 0 to 15,000 fps			40.0	40.0									
A 12-ft TPT	Ames 12-ft Transonic Pressure Tunnel	12 ft diameter	Continuous M = 0 to 1.0					80.0			80.0					FD-6
			Totals	1490	400	540	2430	1790	390	510	2690	557.1	96.0	198.0	851.1	

IV. MODELS

The following models are required for testing to obtain the necessary data for the Apollo program. Figure 3 shows the principal Apollo test configurations: launch configuration, launch escape vehicle, command module, and command module with service module. Figures 4 through 9 show typical models for force, pressure, dynamic, and heat transfer tests.

Static Force (FS) Models

FS-1 A 0.02-scale model of the command module with several detachable launch escape system configurations incorporating provisions for simulation of jet plume from escape motor.

FS-2 A 0.105-scale model of the command module with several detachable launch escape system configurations. The large scale of this model will provide high Reynolds number data.

FS-3 A 0.045-scale model of the command module with detachable launch escape system configurations. This model is designed for high-temperature flow.

FS-4 A lightweight 0.04-scale model of the command module for testing in impulse tunnels.

FS-6 A 0.013-scale model of the command module for testing in high-enthalpy flow in the entry attitude.

FS-7 A 0.02-scale model of the command module with a parametrically varied shape.

FS-8 A lightweight 0.05-scale model of the command module for testing in impulse tunnels.

FS-9 A 0.105-scale model of the command module with apex drogue chute cover removed.

FSC-1 A 0.10-scale drogue chute model with fixed command module. Three parachute diameters with various porosities and various riser elasticities will be tested. The models will include a drag balance for measuring the drag force of the chute.

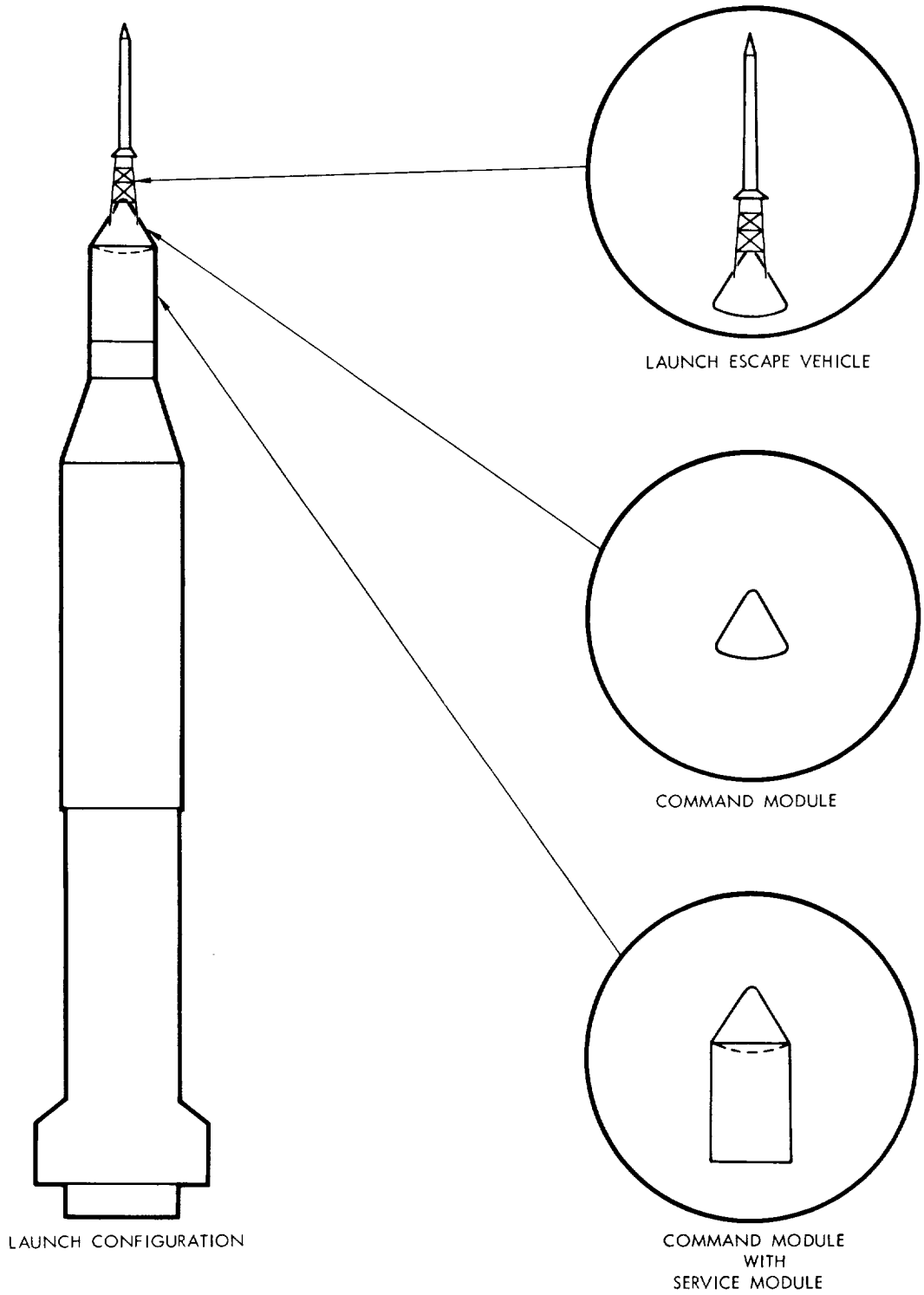

Figure 3. Apollo Test Configurations

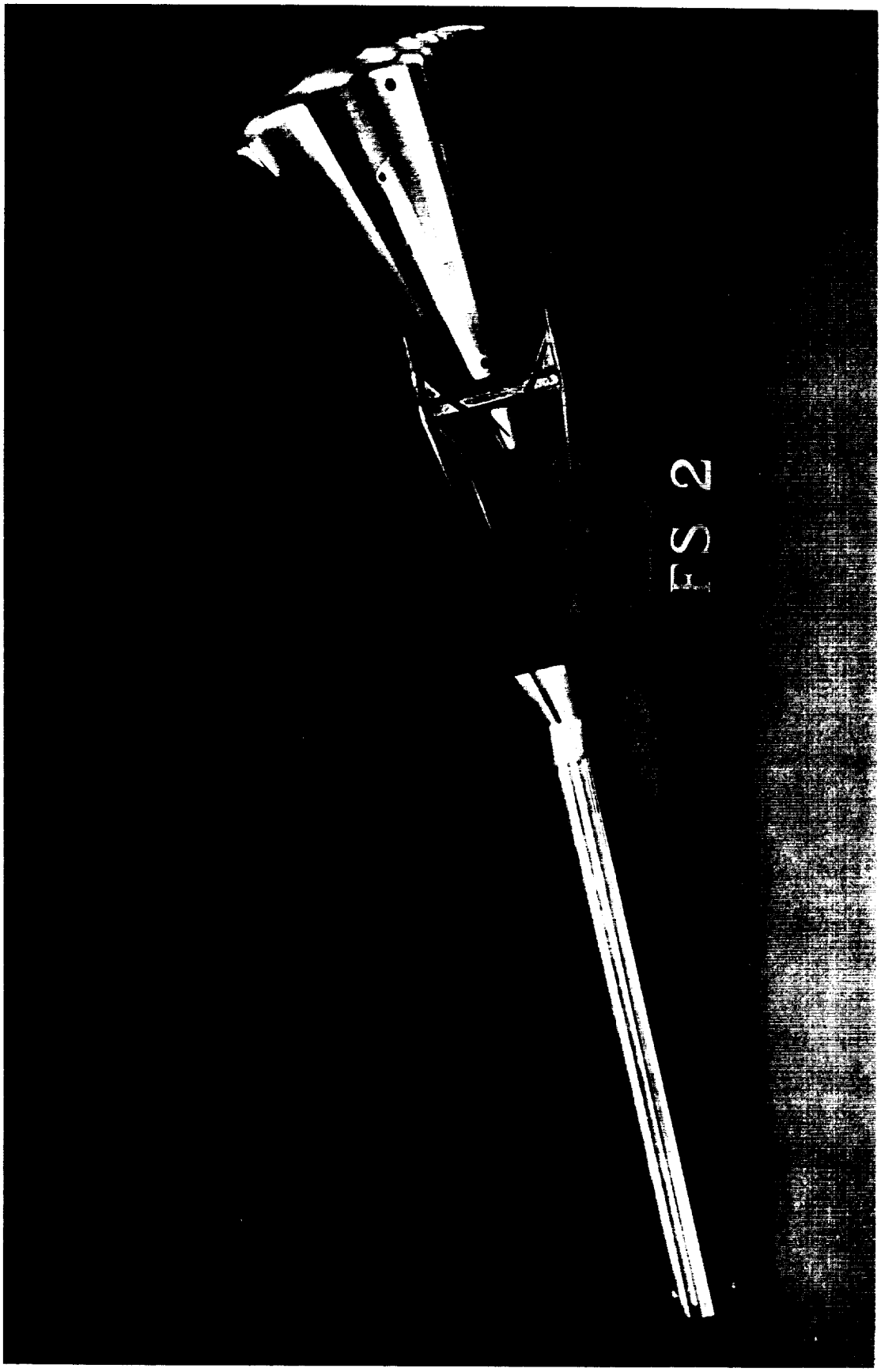

Figure 4. Launch Escape Vehicle 0.105-Scale Static Force Model

93-202 E

Figure 5. Launch Escape Vehicle 0.045-Scale Static Pressure Model

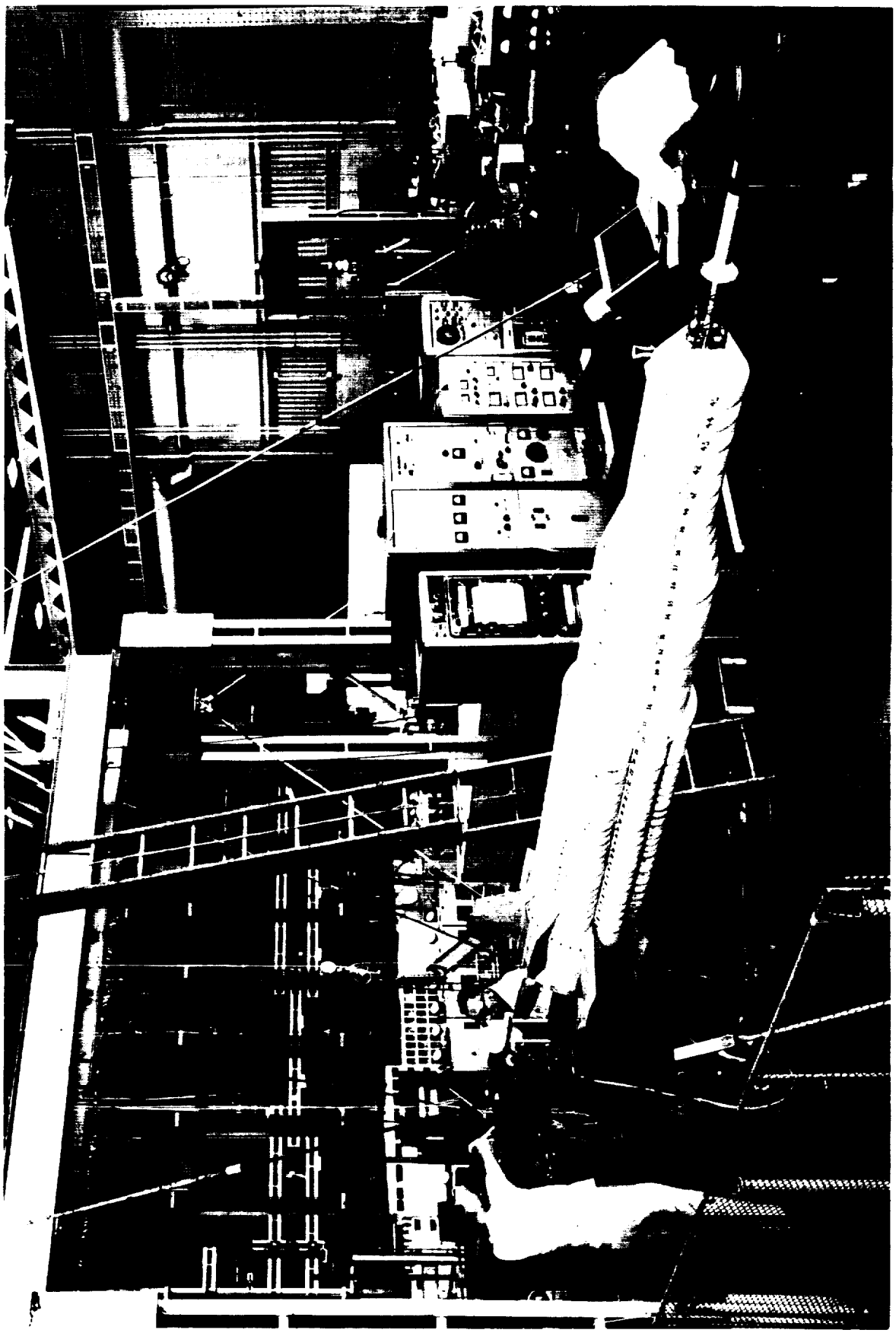

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Figure 6. SA-5 Launch Configuration 0.08-Scale Structural Dynamic Model

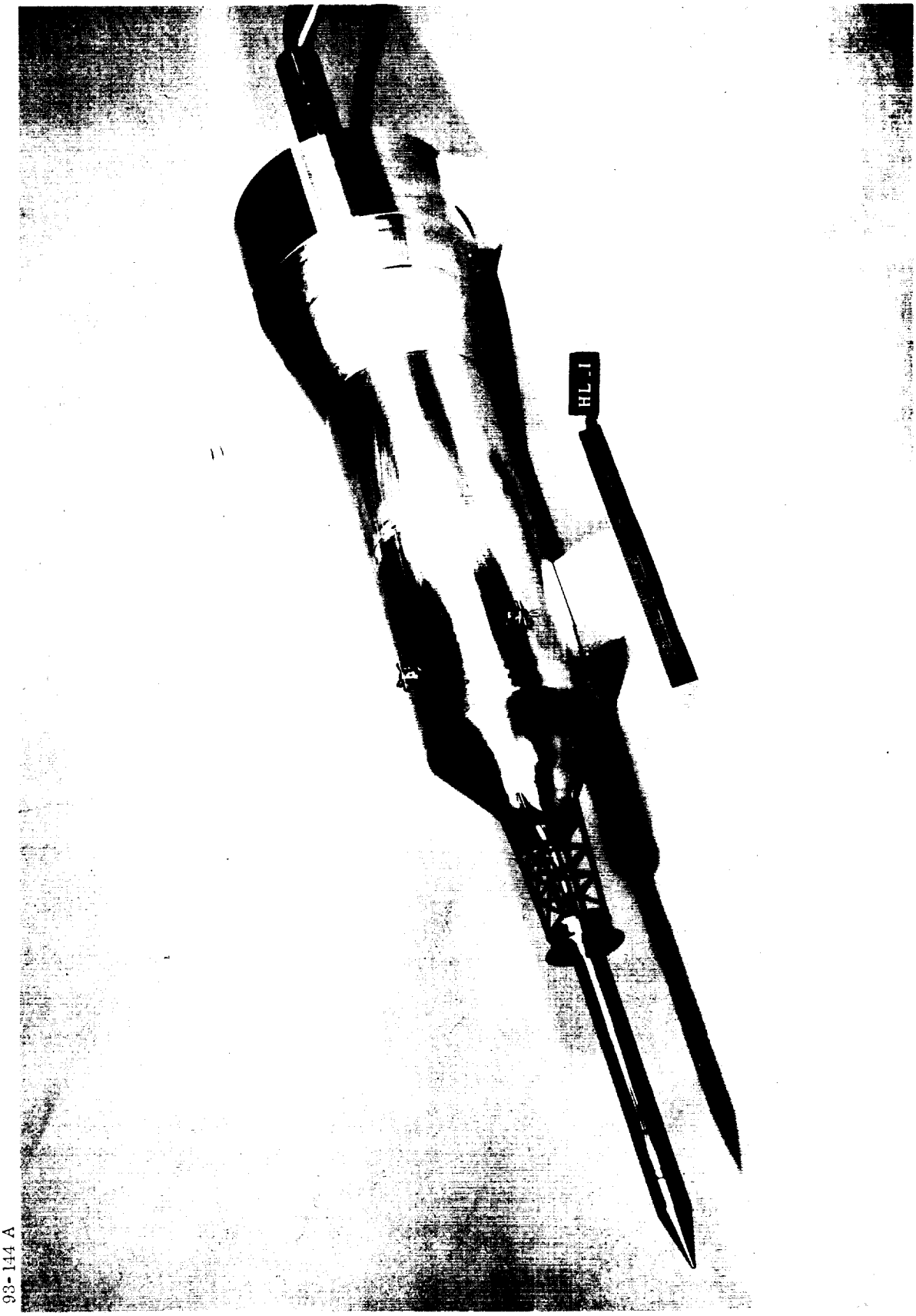


Figure 7. Saturn I Launch Vehicle 0.045-Scale Heat Transfer Model (Forward Portion)

93-197 E

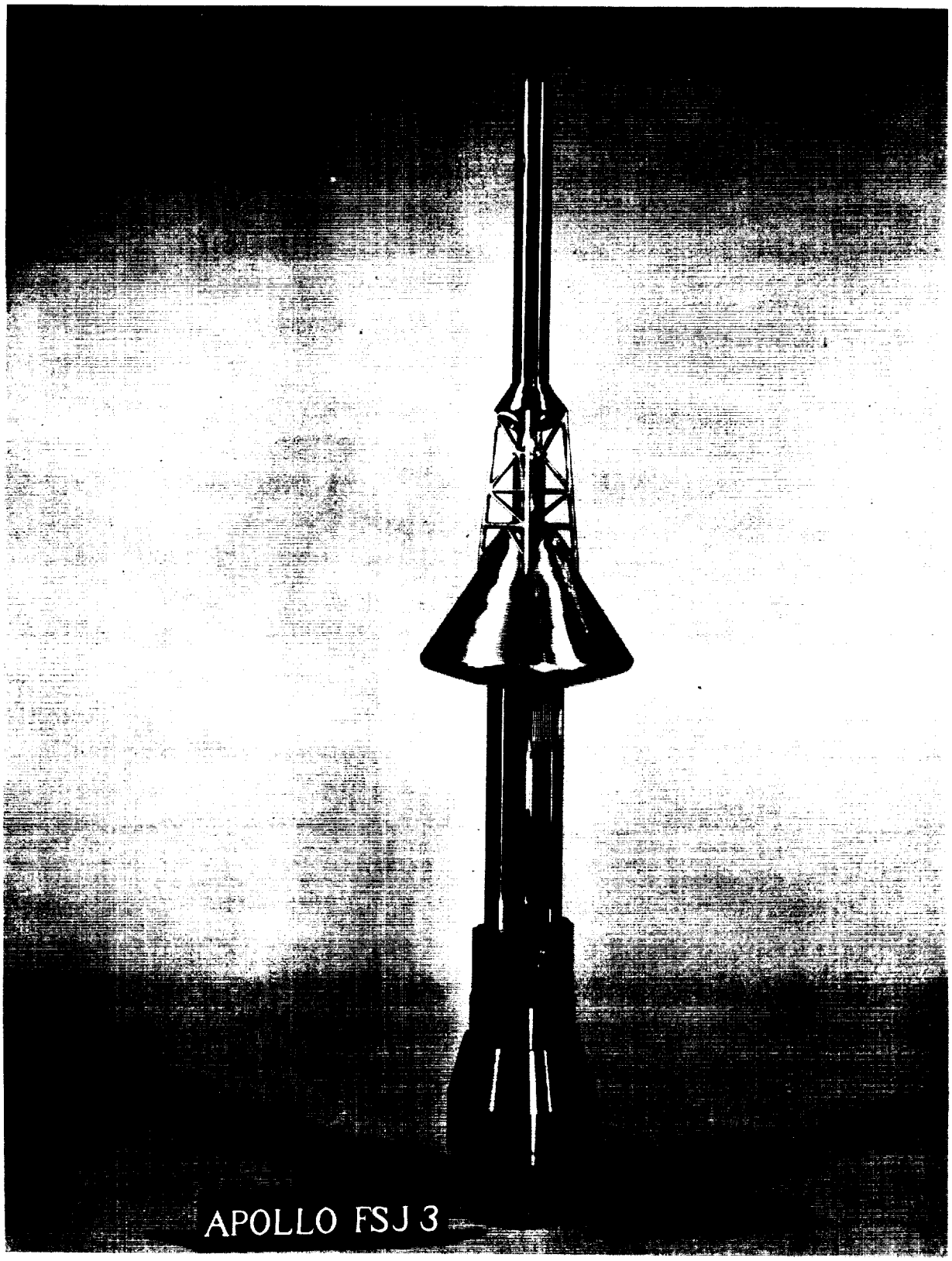
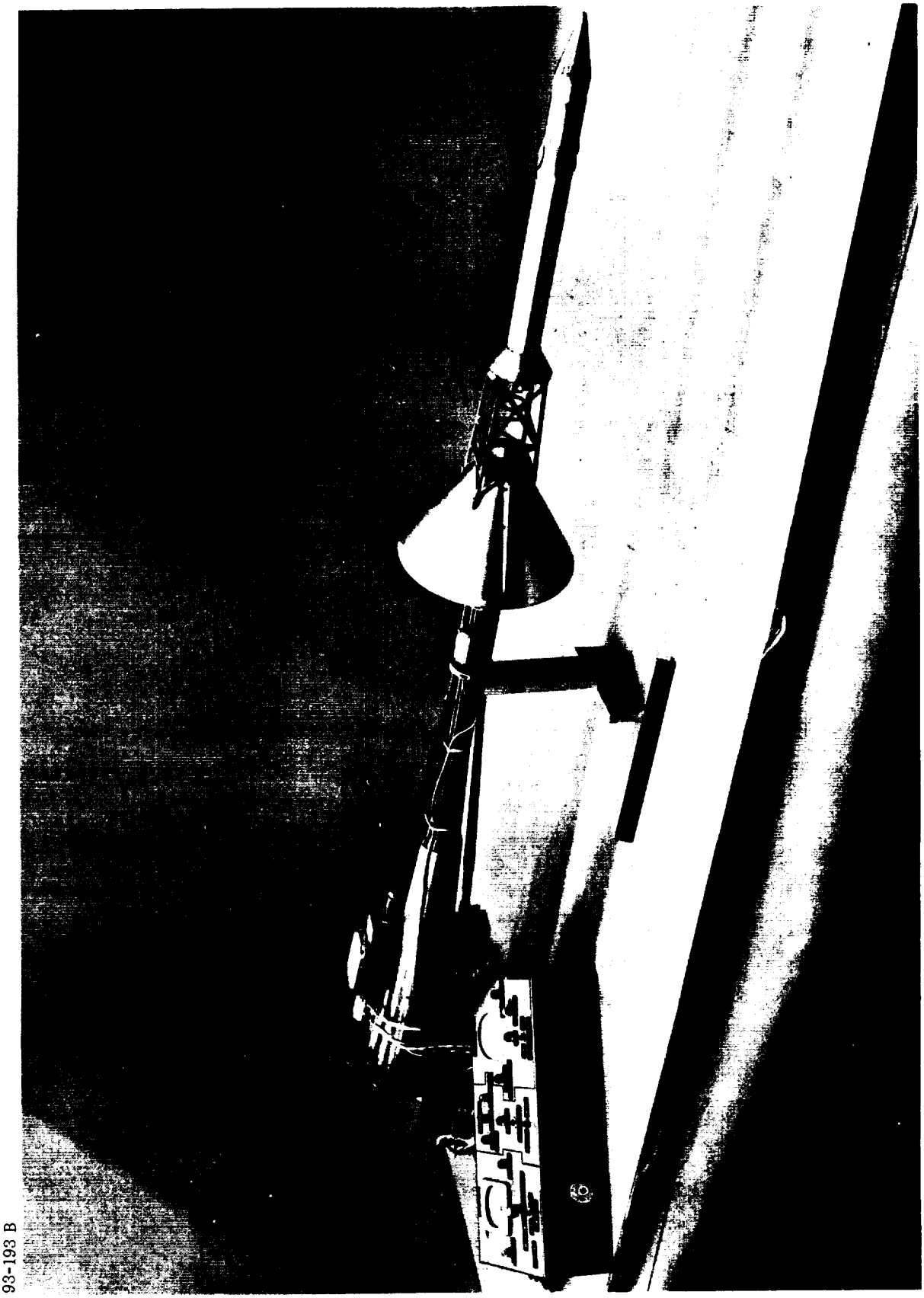


Figure 8. 0.045-Scale Model of the Launch Escape Vehicle With Simulated Escape Rocket Motor Exhaust



93-193 B

Figure 9. Launch Escape Vehicle 0.059-Scale Free-Oscillation Dynamic Model

FDC-1 A 0.10-scale dynamically similar command module with the drogue chute. The command module will be mounted for three degrees of freedom. The drogue chute diameter, porosity, and riser length and elasticity will be determined from the FSC-1 tests.

FSJ-1 A 0.085-scale model of the launch escape vehicle that will be used to determine detailed effects of true simulation of escape motor jet exhaust impingement on the command module in the transonic Mach number range.

FSJ-3 A 0.045-scale model of the launch escape vehicle using unheated air as the launch escape vehicle propellant. Model will be available for incorporation changes as required throughout the program.

FSL-1 A 0.02-scale model of the complete launch (L) configuration with the Saturn C-1 launch vehicle. Provisions for detaching the escape tower, the command module, and the service module will be provided to obtain the characteristics of the C-1 booster alone.

FBR-1 A 0.45-inch-diameter model of the command module for firing from a light gas gun. Model will also include a sabot that will separate from the command module as it leaves the muzzle.

Dynamic Force (FD) Models

FD-1 A 0.03-scale model of the command module with the center of gravity on the centerline and a 0.03-scale command module with an offset center of gravity. Models will be of lightweight construction and will be mounted on an air bearing.

FD-2 A 0.055-scale model of the command module with a detachable escape tower. Model is of lightweight construction and relatively simple construction to permit early testing.

FD-3 A 0.045-scale model of the command module with a detachable escape tower.

FD-4 A 0.10-scale model of the command module with a detachable escape tower.

FD-5 A 0.05-scale model of the command module and a 0.059-scale model of the launch escape vehicle.

FD-6 A 0.10-scale model of the command module.

Structural Dynamic (SD) Models

SD-1 A 0.08-scale model of the SA-5 launch configuration. The model is flexible with scale stiffness distribution and variable mass distribution for simulating the correct mass at Mach numbers 0.8, 1.0, and 1.2. The model is spring-mounted to allow bending in the first and second free-free bending modes as well as pitch oscillation about the center of gravity. Instrumentation includes bending moment strain gages, accelerometers, and transducers for measuring transient pressures. An electromagnetic shaker installed between the sting and model is used to excite the model to obtain aerodynamic damping in pitch.

Static Pressure (PS) Models

PS-1 A 0.02-scale model of the command module with detachable escape tower configurations. This model is instrumented with pressure taps for obtaining pressure distributions on the command module with and without the escape tower installed.

PS-3 A 0.045-scale model of the command module with detachable service module and escape tower configurations. This model is instrumented with pressure taps for obtaining pressure distributions on the escape tower, command module, service module, and flow separator.

PS-4 A 0.04-scale model of the command module. This model is instrumented with miniature pressure transducers to obtain pressure distributions in impulse tunnels.

PS-5 A 0.05-scale model of the command module instrumented with miniature pressure transducers to obtain pressure distributions in impulse tunnels.

PS-6 A 0.01875-scale model of the command module instrumented with miniature pressure transducers to obtain pressure distributions in impulse tunnels.

PS-7 A 0.125-scale model of the command module instrumented with miniature pressure transducers to obtain pressure distributions in impulse tunnels.

Static and Transient Pressure (PST) Models

PSTL-1 A 0.055-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. This model has provisions for detaching the escape tower.

PSTL-2 A 0.055-scale simulation of the Apollo/Saturn IB launch escape from the S-IVB stage forward.

Heat Transfer (H) Models

H-1 A thin-skin 0.02-scale model of the command module instrumented with thermocouples to obtain heat transfer rates. Also a 0.02-scale model of the launch escape vehicle and service module. The service module is instrumented with pressure taps.

H-2 0.045-scale models of the command module and launch escape system and service module. These models are constructed with thin skins and are instrumented with thermocouples to obtain heat transfer rates.

H-3 A 0.013-scale model of the command module for testing in high-temperature flow. This model will be constructed with a thin skin and will be instrumented with thermocouples to obtain heat transfer rates.

H-4 A 0.05-scale model of the command module for testing in impulse tunnels. This model will be instrumented with thin-film resistance thermometers.

H-6 A 0.01875-scale model of the command module instrumented with thin-film platinum resistant heat transfer gages for obtaining heat transfer rates.

H-7 A 0.040-scale thick-skin, stainless steel model of the command module instrumented with thin wafer calorimeters and tested in hot shot tunnels.

H-9 A thin-skin, stainless steel sphere having the same diameter as the entry face of the H-1 model and instrumented with thermocouples.

H-11 0.10-scale fiberglass models of the actual flight configuration instrumented with thin-film platinum heat transfer gages. These models will be used to obtain heat transfer distribution for both launch and entry configurations.

H-12 A 0.020-scale thin-skin, stainless steel model of the command module used to obtain heat transfer distribution at very high stagnation enthalpy. This model will be instrumented with thermocouples.

HBR-1 A 0.45-inch diameter model of the command module for testing in a ballistic range facility. Approximately fifteen of these models will be required.

HL-1 A 0.045-scale model of the launch (L) configuration with only the forward portion of the Saturn I launch vehicle duplicated. This model will be constructed with a thin skin and will be instrumented with thermocouples to obtain heat transfer rates. This model is made with some modified parts of the H-2. These parts are interchangeable with the original H-2 configuration.

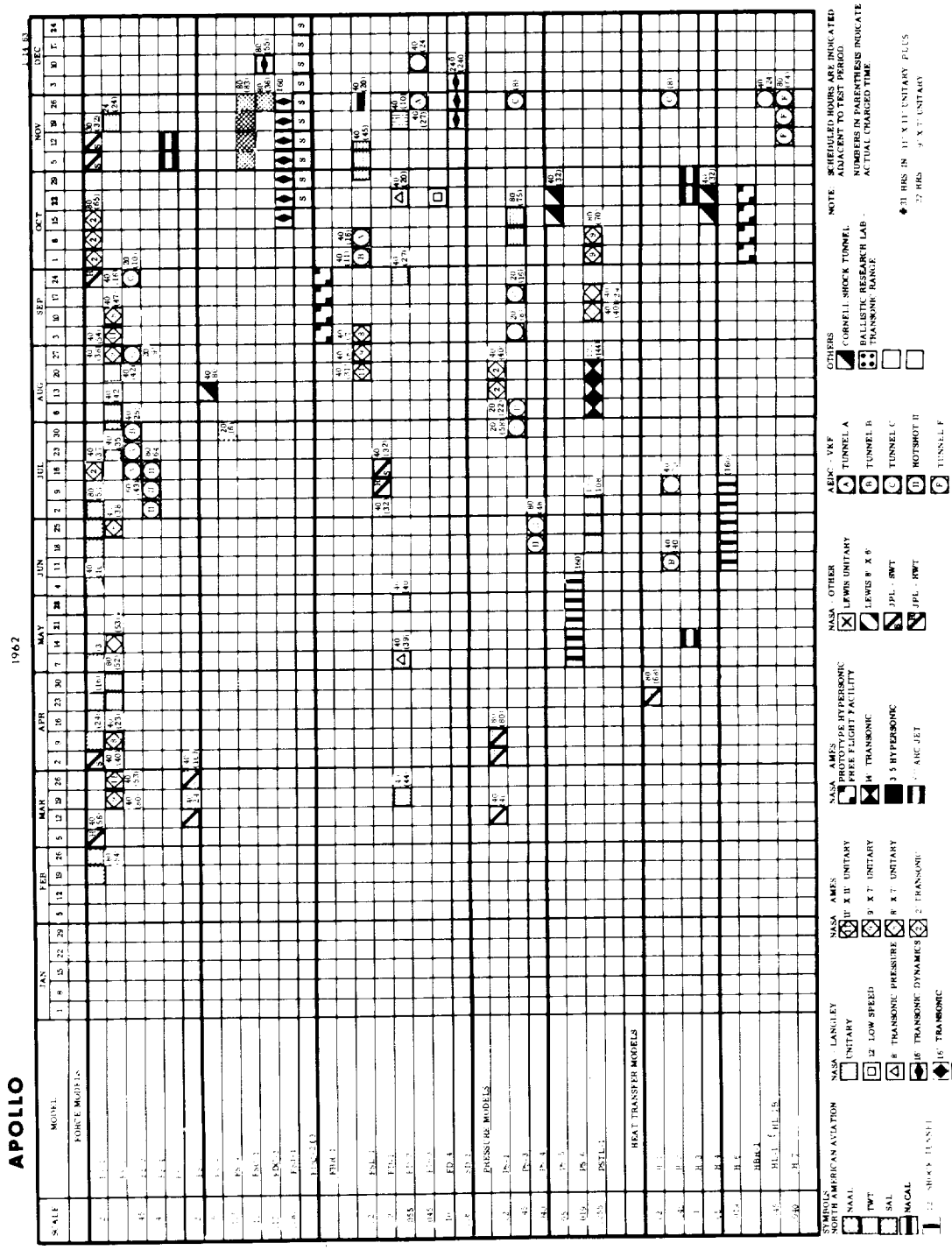
HL-1B A modification of the Saturn booster flare angle from 13 to 25 degrees to accommodate the S-IVB stage.

HBR-2 A 0.02-scale model of the command module for testing in a ballistic range facility. This model will be instrumented to measure convective heat transfer rates.

V. TEST SCHEDULE

The wind tunnel test schedule has been coordinated with Engineering to meet their requirements for design information. The schedule for the complete program, based on current planning, is shown in Tables 6, 7, and 8. As development of the Apollo program progresses, changes in the proposed tests and test facilities will be made as necessary.

Table 6. Wind Tunnel Test Schedule 1962



APOLLO

Table 7. Wind Tunnel Test Schedule 1963

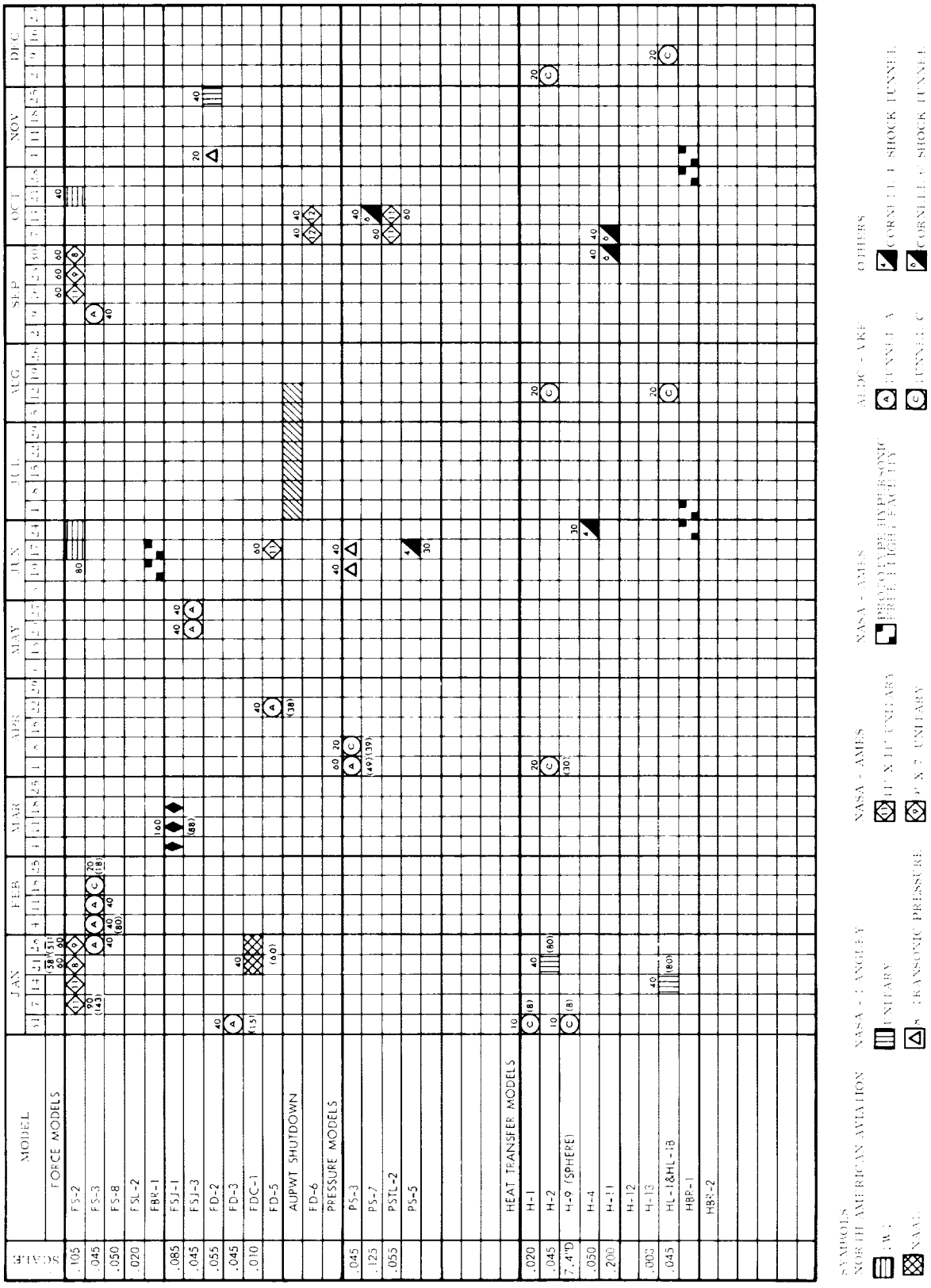
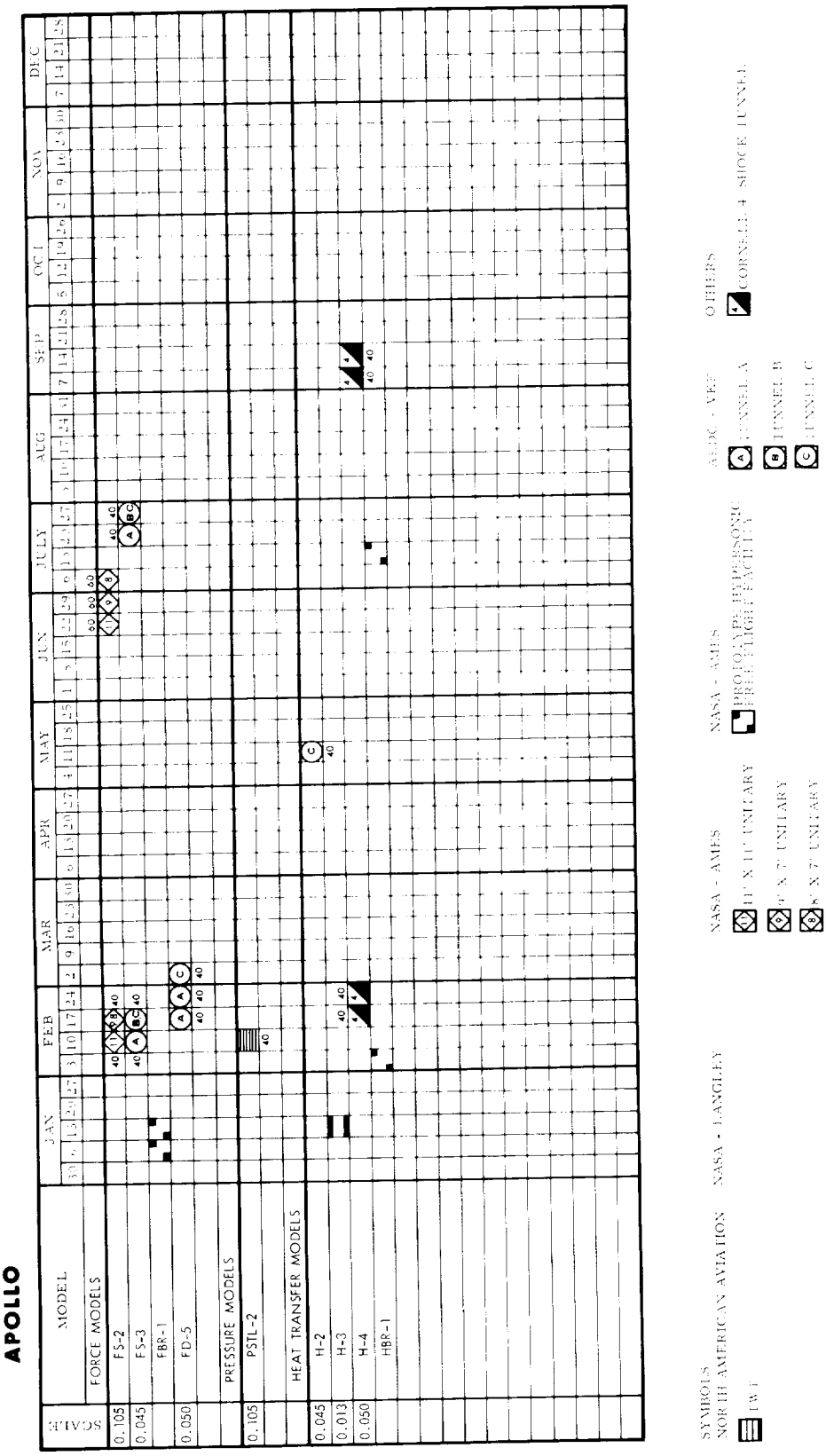


Table 8. Wind Tunnel Test Schedule 1964



VI. REPORTS

A listing of the reports associated with testing of the Apollo models is shown in Tables 9, 10, and 11. The listing is divided into the two types of reports required: (1) a pretest report that contains information needed to conduct the test successfully and a structural analysis report necessary for successful design of the model that are published before the test, (2) a data report that contains a tabulation of the test data and is published after each test. The reports are listed as pertaining to force, pressure, or heat transfer tests. If a report covers more than one of these tests, it is listed under each of the applicable headings.

Table 9. Force Tests

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FS-1	SAL	18 Feb 1962 to 6 Mar 1962	NA-62-82		"Test and Model Information for Wind Tests of a 0.02-Scale Force Model (FS-1) of the Apollo in the North American Aviation Supersonic Aerophysics Laboratory" (25 Jan 1962)	SID-62-343	29 Mar 1962 PS-CF-62-26571	"Tabular Data Report for Apollo Model (FS-1) Wind Tunnel Test (SAL 199)" (26 Mar 1962)
FD-2			SID-62-103	18 Sep 1962 PS-CF-62-30158	"Structural Analysis of 0.055-Scale Apollo Wind Tunnel Models" (4 Sep 1962)			
FD-2			SID-62-104	9 Aug 1962 PS-CF-62-29269	"Structural Analysis of 0.105-Scale Apollo Wind Tunnel Model (FS-2)" (1 Aug 1962)			
FS-1	JPL-HWT	5 Mar 1962 to 13 Mar 1962	SID-62-246	2 Mar 1962 PS-CF-62-26177	"Pretest Report for a 0.02-Scale Apollo Force Model (FS-1) in the JPL Wind Tunnel" (12 Feb 1962)	SID-62-423	13 Apr 1962 PS-CF-62-26994	"Data Report for Wind Tunnel Tests (JPL 21-98) of Apollo Models FS-1 and FS-7" (2 Apr 1962)
FS-7	JPL-HWT	14 Mar 1962 to 16 Mar 1962	SID-62-246	2 Mar 1962 PS-CF-62-26177	"Pretest Report for a 0.02-Scale Apollo Force Model (FS-1) in the JPL Wind Tunnel" (12 Feb 1962)	SID-62-423	12 Apr 1962 PS-CF-62-26994	"Data Report for Wind Tunnel Tests (JPL 21-98) of Apollo Models FS-1 and FS-7" (2 Apr 1962)
FD-2	LUPWT	15 Mar 1962 to 19 Mar 1962	None			SID-62-536	31 May 1962 PS-CF-62-27859	"Data Report for Langley Unitary Plan Wind Tunnel Tests (Project 349) of Apollo Model (FD-2) NAS9-150" (28 May 1962)
FS-2	AUPWT	19 Mar 1962 to 23 Mar 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105-Scale Force Model (FS-2) of the Apollo in the Ames 11 by 11 ft, 9 by 7 ft, and 8 by 7 ft Unitary Plan Wind Tunnel" (6 Feb 1962)	SID-62-601	12 June 1962 PS-CF-62-28296	"Data Report for Apollo Model (FS-2) in the Ames Unitary Plan Wind Tunnels" (26 Apr 1962)
FS-2	AUPWT	26 Mar 1962 to 30 Mar 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105-Scale Force Model (FS-2) of the Apollo in the Ames 11 by 11 ft, 9 by 7 ft, and 8 by 7 ft Unitary Plan Wind Tunnels" (6 Feb 1962)	SID-62-601	15 June 1962 PS-CF-62-28296	"Data Report for Apollo Model (FS-2) in the Ames Unitary Plan Wind Tunnels" (26 Apr 1962)
FS-1	JPL-SWT	26 Mar 1962 to 4 Apr 1962	SID-62-246	2 Mar 1962 PS-CF-62-26177	"Pretest Report for a 0.02-Scale Apollo Force Model (FS-1) in the JPL Wind Tunnel" (12 Feb 1962)	SID-62-547	9 May 1962 PS-CF-62-27413	"Data Report for Apollo Models FS-1 and FS-7 Wind Tunnel Test (JPL 20-495)" (27 Apr 1962)

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FS-7	JPL-SWT	26 Mar 1962 to 4 Apr 1962	SID-62-246	2 Mar 1962 PS-CF-62-26177	"Pretest Report for a 0.02-Scale Apollo Force Model (FS-1) in the JPL Wind Tunnel" (12 Feb 1962)	SID-62-547	9 May 1962 PS-CF-62-27413	"Data Report for Apollo Models FS-1 and FS-7 Wind Tunnel Test (JPL 20-495)" (27 Apr 1962)
FS-1	SAL	6 Apr 1962 to 16 Apr 1962	NA-62-82		"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Force Model (FS-1) of the Apollo in the NAA Supersonic Aerophysics Laboratory" (25 Jan 1962)	SID-62-753	17 Sep 1962 PS-CF-62-30134	"Data Report for the Stability Tests (FS-1) in the SAL Wind Tunnel" (4 Jun 1962)
FS-2	AUPWT	9 Apr 1962 to 10 Apr 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105-Scale Force Model (FS-2) of the Apollo in the Ames 11-by 11-ft, 9-by 7-ft, and 8-by 7-ft Unitary Plan Wind Tunnels" (6 Feb 1962)	SID-62-601	15 Jun 1962 PS-CF-62-28296	"Data Report for Apollo Model (FS-2) in the Ames Unitary Plan Wind Tunnels" (31 May 1962)
FS-1	SAL	24 Apr 1962 to 26 May 1962	None			SID-62-753	17 Sep 1962 PS-CF-62-30134	"Data Report for the Stability Tests (FS-1) in the SAL Wind Tunnel" (4 Jun 1962)
FS-4			SID-62-331	10 Sep 1962	"Structural Analysis of the 0.040 Scale Apollo Wind Tunnel Models FS-4 and PS-4" (31 Aug 1962)			
FS-2	TWT	20 Apr 1962 to 1 May 1962	SID-62-353	23 Mar 1962 PS-CF-62-26570	"Pretest Report 0.105-Scale Apollo Force Model (FS-2) in NAA Trisonic Wind Tunnel" (20 Mar 1962)	SID-62-627	9 Aug 1962 PS-CF-62-29290	"Data Report for Apollo Force Model (FS-2) in NAA Trisonic Wind Tunnel (TWT-74)" (2 Aug 1962)
FD-2	LTPT	3 May 1962 to 8 May 1962	None			SID-62-1065	29 Aug 1962 PS-CF-62-29771	"Data Report for Langley 8-ft TPT Wind Tunnel Tests (Project 233) of Apollo Model (FD-2)" (24 Aug 1962)
FS-2	AUPWT	10 May 1962 to 14 May 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105 Scale Force Model (FS-2) of the Apollo in the Ames 11-by 11-ft, 9-by 7-ft, and 8-by 7-ft Unitary Plan Wind Tunnels" (6 Feb 1962)	SID-62-778	10 Aug 1962 PS-CF-62-29321	"Data Report for Apollo Model (FS-2) in the Ames Unitary Plan Wind Tunnels" (1 Aug 1962)

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FS-1	SAL	11 May 1962 to 15 May 1962	None			SID-62-753	17 Sep 1962 PS-CF-62-30134	"Data Report for the Stability Tests (FS-1) in the SAL Wind Tunnel (4 Jun 1962)
FS-2	AUPWT	15 May 1962 to 16 May 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105-Scale Force Model (FS-2) of the Apollo in the Ames 11-by 11-ft, 9-by 7-ft, and 8-by 7-ft Unitary Plan Wind Tunnels" (6 Feb 1962)	SID-62-778	10 Aug 1962 PS-CF-62-29321	"Data Report for Apollo Model (FS-2) in the Ames Unitary Plan Wind Tunnels" (1 Aug 1962)
FD-2	LUPWT	28 May 1962 to 1 Jun 1962	None			SID-62-1074	29 Aug 1962 PS-CF-62-29780	"Data Report for Langley Unitary Plan Wind Tunnel Tests (Project 374) of Apollo Model (FD-2)" (24 Aug 1962)
FS-1	SAL	6 Jun 1962 to 8 Jun 1962	None			SID-62-1063	28 Aug 1962 PS-CF-62-29763	"Data Report for Apollo Model FS-1 Test (SAL 1207)" (21 Aug 1962)
FS-1	SAL	14 Jun 1962 to 8 Jul 1962	None			SID-62-1056	29 Aug 1962 PS-CF-62-29763	"Data Report for Simulated Jet Plumes on the Apollo Model (FS-1) Wind Tunnel Test (SAL 1208)" (20 Aug 1962)
FS-2	AUPWT	21 Jun 1962 to 27 Jun 1962	SID-62-100	5 Mar 1962 PS-CF-62-26209	"Test and Model Information for Wind Tunnel Tests of an 0.105-Scale Force Model (FS-2) of the Apollo in the Ames 11-by 11-ft, 9-by 7-ft, and 8-by 7-ft Unitary Plan Wind Tunnels" (6 Feb 1962)	SID-62-936	29 Aug 1962 PS-CF-62 29771	"Data Report for Apollo Model (FS-2) in the Ames 8-by 7-ft Unitary Plan Wind Tunnel" (23 Aug 1962)
FD-1			SID-62-388	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the Apollo 0.03-Scale Dynamic Stability Model (FD-1)" (28 Aug 1962)			
FD-1	AEDC-HS II	2 Jul 1962 to 17 Jul 1962	SID-62-424	30 Apr 1962 PS-CF-62-27235	"Pretest Report for Apollo Force Model FS-4 in the Arnold Center VKF Hotshot II' (3 Apr 1962)	SID-62-977	30 Aug 1962 PS-CF-62-29802	"Data Report for Wind Tunnel Tests of Apollo Model FS-4 in the AEDC-Hotshot II" (24 Aug 1962)
FD-4	JPL-HWT	10 Jul 1962 to 13 Jul 1962	SID-62-549	4 May 1962 PS-CF-62-27337	"Pretest Report for a 0.03-Scale Apollo Dynamic Stability Model (FD-1) in the JPL Wind Tunnels" (24 Apr 1962)			Data report to be published by Langley.

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FD-1	JPL-SWT	16 Jul 1962 to 19 Jul 1962	SID-62-549	4 May 1962 PS-CF-62-27337	"Pretest Report for a 0.030-Scale Apollo Dynamic Stability Model (FD-1) in the JPL Wind Tunnels" (24 Apr 1962)	SID-62-1358		"Data Report for JPL Tests of a 0.030-Scale Apollo Dynamic Stability Model (FD-1) in the 20-Inch Supersonic (Test No. 20-516) and the 21-Inch Hypersonic (Test No. 21-113) Tunnels" (Jan 1963)
SD-1	L16-Ft TDT		SID-62-558		"Structural Analysis of 0.05-Scale Structural Dynamics Apollo Model" (25 Apr 1962)			
FS-3			SID-62-777	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the 0.045-Scale Apollo Force and Pressure Models (FS-3 and PS-3)" (28 Aug 1962)			
FS-1	A2-Ft TWT	17 Jul 1962 to 23 Jul 1962	None			SID-62-1027	25 Sep 1962 PS-CF-62-30284	"Data Report for Apollo Model (FS-1) Wind Tunnel Tests (Ames 2- by 2- ft-396)" (24 Aug 1962)
FS-3	AEDC-A	17 Jul 1962 to 26 Jul 1962	SID-62-709	13 Jun 1962 PS-CF-62-28214	"0.045-Scale Apollo Force Model FS-3 Wind Tunnel Tests in the von Karman Gas Dynamics Facility Tunnels A, B, and C" (11 June 1962)	SID-62-1057		"Data Report for Apollo Model FS-3 Wind Tunnel Tests in the A Tunnel of the AEDC von Karman Gas Dynamics Facility" (17 Sep 1962)
FS-2	NAAL	17 Jul 1962 to 30 Jul 1962	SID-62-738		"Pretest Report for the 0.105-Scale Apollo Force Model (FS-2) NAAL 11- by 7.75-ft Wind Tunnel" (25 Jun 1962)	SID-62-1128	14 Dec 1962 PS-CF-62-32369	"Data Report for Apollo Model (FS-2) in the NAAL Wind Tunnel (NAAL 485)" (10 Dec 1962)
FS-9	NAAL	27 Jul 1962 to 30 Jul 1962	None			SID-62-1129	26 Nov 1962 PS-CF-62-31681 27 Dec 1962 PS-CF-62-32411	"Data Report for Apollo Model (FS-9) in the NAAL Wind Tunnel (NAAL 487)" (15 Nov 1962) Revised (17 Dec 1962)
FS-3	AEDC-B	30 Jul 1962 to 1 Aug 1962				SID-62-1247	14 Dec 1962 PS-CF-62-32357	"Data Report for Apollo Model FS-3 Wind Tunnel Tests in Tunnels B and C of the AEDC von Karman Gas Dynamics Facility" (10 Dec 1962)
FS-2	TWT	6 Aug 1962 to 13 Aug 1962				SID-62-1216	27 Dec 1962 PS-CF-62-32411	Data Report for Apollo 0.105-Scale FS-2 Model in the North American Aviation Trisonic Wind Tunnel, TWT 79" (17 Dec 1962)

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FS-8	CAL-ST	15 Aug 1962 to 22 Aug 1962	SID-62-754	22 Jun 1962 PS-CF-62-28216	"Pretest Report for the 0.05-Scale Apollo Model (FS-8) in the Cornell Aeronautical Laboratory 48-in. Hypersonic Shock Tunnel" (12 Jun 1962)	AA-1712-W-1		"Hypersonic Shock Tunnel Tests of the 0.05-Scale Apollo Force Model FS-8" (Oct 1962)
FS-2	TWT	21 Aug 1962 to 27 Aug 1962	None			SID-62-1212	29 Dec 1962 PS-CF-62-31724 27 Dec 1962 PS-CF-62-32415	"Data Report for Apollo Model (FS-2) in NAA Trisonic Wind Tunnel (TWT 80) Revised (17 Dec 1962)
FSL-1	AUPWT	22 Aug 1962 to 24 Aug 1962	SID-62-805	16 Aug 1962 PS-CF-62-29470	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Force Model (FSL-1) of the Apollo in the Ames 11-, 9- by 7- and 8- by 7-ft Wind Tunnels" (13 Aug 1962)	SID-62-1143	11 Oct 1962 PS-CF-62-30686	"Data Report for the Apollo Model (FSL-1) Wind Tunnel Tests in the Ames 11- by 9- by 7-ft and 8- by 7-ft Unitary Plan Wind Tunnels" (Sept 1962)
FS-2	AUPWT	27 Aug 1962 to 29 Aug 1962	SID-62-1007 and SID-62-1009	24 Aug 1962 PS-CF-62-29648	"Pretest Report for the 0.105-Scale Apollo Force Model FS-2 in the Ames 11-, 9- by 7- and 8- by 7-ft UPWT" (19 Jul 1962)	SID-63-145		"Data Report for the Apollo Model FS-2 Tests in the Ames Unitary Plan Wind Tunnels to Measure Launch Escape Vehicle Component Loads" (Apr 1963)
FS-3	AEDC-C	31 Aug 1962	SID-62-709	13 Jun 1962 PS-CF-62-28214	"0.045-Scale Apollo Force Model FS-3 Wind Tunnel Tests in the von Karman Gas Dynamics Facility Tunnels A, B, and C" (11 Jun 1962)	SID-62-1247	14 Dec 1962 PS-CF-62-32357	"Data Report for Apollo Model FS-3 Wind Tunnel Tests in Tunnels B and C of the AEDC von Karman Gas Dynamics Facility" (10 Dec 1962)
FSL-1	AUPWT	30 Aug 1962 to 31 Aug 1962	SID-62-805	16 Aug 1962 PS-CF-62-29470	"Test and Model Information for Wind Tunnel Tests of an 0.02-Scale Force Model (FSL-1) of the Apollo in the Ames 11-, 9- by 7-, and 8- by 7-ft Wind Tunnels" (13 Aug 1962)	SID-62-1143	11 Oct 1962 PS-CF-62-30686	"Data Report for the Apollo Model (FSL-1) Wind Tunnel Tests in the Ames 11- by 9- by 7-ft and 8- by 7-ft Unitary Plan Wind Tunnels" (Sept 1962)
FS-2	AUPWT	30 Aug 1962 to 10 Sep 1962	SID-62-1007 and SID-62-1009	24 Aug 1962 PS-CF-62-29648	"Pretest Report for the 0.105-Scale Apollo Force Model FS-2 in the Ames 11-, 9- by 7-, and 8- by 7-ft UPWT" (19 Jul 1962)	SID-63-145		"Data Report for Apollo Model FS-2 Tests in the Ames Unitary Plan Wind Tunnels to Measure Launch Escape Vehicle Components Loads" (Apr 1963)

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FSL-1	AUPWT	5 Sep 1962	SID-62-805	16 Aug 1962 PS-CF-62-29470	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Force Model (FSL-1) of the Apollo in the Ames 14- by 9- by 7-, and 8- by 7-ft Wind Tunnels" (13 Aug 1962)	SID-62-1143		"Data Report for the Apollo Model (FS-1) Wind Tunnel Tests in the Ames 11- by 4- by 7-ft and 8- by 7-ft Unitary Plan Wind Tunnels" (Sep 1962)
FS-1			SID-62-251	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the 0.02-Scale Apollo Wind Tunnel Models (FS-1 and PS-1)" (28 Aug 1962)			
FS-2	AUPWT	11 Sep 1962 to 12 Sep 1962	SID-62-1007 and SID-62-1009	24 Aug 1962 PS-CF-62-29648	"Pretest Report for the 0.105-Scale Apollo Force Model FS-2 in the Ames 11-, 9- by 7- and 8- by 7-ft UPWT" (19 Jul 1962)	SID-63-145		"Data Report for the Apollo Model FS-2 Tests in the Ames Unitary Plan Wind Tunnels to Measure Launch Escape Vehicle Component Loads" (Apr 1963)
FS-3	AEDC-C	24 Sep 1962	SID-62-709	13 Jun 1962 PS-CF-62-28214	"0.045-Scale Apollo Force Model FS-3 Wind Tunnel Tests in the von Karman Gas Dynamics Facility Tunnels A, B, and C" (11 Jun 1962)	SID-62-1247	14 Dec 1962 PS-CF-62-32357	"Data Report for Apollo Model FS-3 Wind Tunnel Tests in Tunnels B and C of the AEDC von Karman Gas Dynamics Facility" (10 Dec 1962)
FD-2	LUPWT	24 Sep 1962 to 25 Sep 1962	None			SID-63-96		"Data Report of 0.055-Scale Apollo Dynamic Stability (FD-2) Model Tests in the Langley Unitary Plan Wind Tunnel - Low Mach Leg To Determine Flow Separation Effects (Project 398)" (10 Apr 1963)
FS-1	JPL-HWT	27 Sep 1962 to 28 Sep 1962	None			SID-62-1256	29 Nov 1962 PS-CF-62-31724	"Data Report for Apollo Model FS-1 Lift-to-Drag Ratio Improvement Test (JPL 20-127) (1 Nov 1962)
FS-1	A2-ft TWT	1 Oct 1962 to 18 Oct 1962	Aero 62-194			SID-62-1403		"Data Report for Apollo Model FS-1 Apex-Forward Trim Point Investigation (Test 577) in the Ames 2- by 2-ft Wind Tunnel" (27 Dec 1962)
FSL-1	AEDC-B	1 Oct 1962 to 2 Oct 1962	SID-62-806	16 Aug 1962 PS-CF-62-29470	"Test and Model Information for Wind Tunnel Tests of a 0.02 Scale Force Model (FSL-1) in the Arnold Center VKF Wind Tunnels A, B, and C" (13 Aug 1962)	SID-62-1144		"Data Report for the FSL-1 Model Wind Tunnel Tests in the A and B Tunnels of the AEDC VKF" (Apr 1963)
FSL-1	AEDC-A	5 Oct 1962 to 9 Oct 1962	SID-62-806	16 Aug 1962 PS-CF-62-29470	Same as above	SID-62-1144		Same as above

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FD-2	LTPT	23 Oct 1962 to 25 Oct 1962	None			SID-63-163		"Data Report for Tests of a 0.055-Scale Apollo Dynamic Stability Model (FD-2) to Determine Flow Separator Effects-Langley 8-Foot Transonic Pressure Tunnel (Project 258)" (Apr 1963)
FSL-1	TWT	1 Nov 1962 to 13 Nov 1962	SID-62-670	19 Oct 1962 PS-CF-62-30756	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Forced Model FSL-1 of the Apollo in the NAA Trisonic Wind Tunnel" (11 Oct 1962)	SID-63-35		"Data Report for the Static Stability Investigation of a 0.20-Scale Model of the Saturn - Apollo Block II Launch Configuration in the NAA Trisonic Wind Tunnel" (Mar 1962)
FSL-1	TWT		SID-62-673-1	18 Sep 1962 PS-CF-62-30158	"Structural Analysis of the 0.02-Scale FSL-1 Model TWT Wind Tunnel Test" (28 Aug 1962)			
FSC-1	NAAL	5 Nov 1962 to 3 Dec 1962	None			SID-63-274		
FS-1	JPL-SWT	7 Nov 1962 to 13 Nov 1962	Aero 62-240			SID-62-1447		"Data Report for Apollo Model FS-1 Apex-Forward Trim Point Investigation (JPL 20-536)" (8 Jan 1963)
FD-2	LUPWT	16 Nov 1962	None			SID-63-147		"Data Report of 0.055-Scale Apollo Dynamic Stability Model (FD-2) Tests to Determine Flow Separator Effects - High Mach Leg of the Langley Unitary Plan Wind Tunnel (Project 411)" (Apr 1963)
SD-1	L16-ft TDT	17 Nov 1962 to 7 Nov 1962	SID-62-841	21 Aug 1962 PS-CF-62-29491 PS-CF-62-30030	"Pretest Report for a 0.08-Scale Apollo Structural Dynamics Model (SD-1) in the NASA Langley Transonic Dynamic Wind Tunnel" (16 Aug 1962) (Revised 12 Nov 1962)			Data and Analysis Report to be Published by Langley.
FS-2	TWT	19 Nov 1962 to 29 Nov 1962	None			SID-63-84		"Data Report of Apollo FS-2 Static Force Model in NAA Trisonic Wind Tunnel (TWT 85)" (Apr 1963)
FD-3			SID-62-1319	14 Dec 1962 PS-CF-62-32365	"Structural Analysis of the Apollo 0.045- and 0.059-Scale Dynamic Stability Models (FD-3)" (10 Dec 1962)			

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FD-3	AEDC-A	26 Nov 1962 to 30 Nov 1962	SID-62-1299	20 Nov 1962 PS-CF-62-31576	Pretest Report for the Dynamic Stability Tests of the Command Module and Launch Escape Vehicle (FD-3 Model) in the AEDC-VKF A and C Tunnels" (2 Nov 1962)	SID 63-616		
FSL-1	NACAL	27 Nov 1962 to 28 Nov 1962	SID-62-669	24 Oct 1962 PS-CF-62-30943	"Test and Model Information for Wind Tunnel Tests of an 0.02-Scale Force Model (FSL-1) of the Apollo in the NACAL Wind Tunnel" (11 Oct 1962)	SID 62-1436		"Data Report for the Apollo Model (FSL-1) Wind Tunnel Tests in the NACAL 7- by 10-ft Subsonic Test Section" (Feb 1963)
			SID-62-1372	27 Dec 1962 PS-CF-62-32355	Structural Analysis of the Apollo 0.10-Scale FDC-1 Dynamic Stability Drogue Chute Model" (10 Dec 1962)			
FDC-1			SID-62-1372	27 Dec 1962 PS-CF-62 32355	"Structural Analysis of the Apollo 0.10-Scale FDC-1 Dynamic Stability Drogue Chute Model" (10 Dec 1962)			
FDC-1	NAAL	27 Nov 1962 to 29 Nov 1962	None			SID 63-279		
FDC-1	L16-ft TDT	10 Dec 1962 to 14 Dec 1962	SID-62-1346	27 Dec 1962 PS-CF-62-32411	"Pretest Report for the 0.10-Scale Apollo Drogue Parachute Model FDC-1 in the Langley 16-ft Transonic Dynamic Tunnel" (27 Dec 1962)	SID 63-319		
FD-3	AEDC-C	11 Dec 1962 to 12 Dec 1962	SID-62-1299	20 Nov 1962 PS-CF-62-31576	"Pretest Report for the Dynamic Stability Tests of the Command Module and Launch Escape Vehicle (FD-3 Model) in the AEDC-VKF A and C Tunnels" (2 Nov 1962)	SID 63-616		
FSJ-1	L16-ft TWT		SID-62-876	11 Sep 1962 PS-CF-62-29995	"Pretest Report for 0.085-Scale Apollo Force Model FSJ-1, Wind Tunnel Tests in the NASA Langley Research Center 16 ft Transonic Tunnel" (10 Aug 1962)			

Table 9. Force Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
FSJ-1	L16-ft TWT		SID-62-1043	6 Nov 1962 PS-CF-62-31223	"Structural Analysis of the Apollo 0.085-Scale FSJ-1 Force Model" (29 Oct 1962)			
FD-3	AEDC-A	4 Jan 1963 to 5 Jan 1963	SID-62-1299			SID-63-616		
FS-2	AUPWT	7 Jan 1963 to 29 Jan 1963	SID-63-28					
FDC-1	NAAL	21 Jan 1963 to 1 Feb 1963	None			SID-63-279		
FS-3	AEDC-A	28 Jan 1963 to 14 Feb 1963 and 8 Mar 1963	SID-62-709		"0.045-Scale Apollo Force Model FS-3 Wind Tunnel Tests in the von Karman Gas Dynamics Facility Tunnels A, B, and C" (Jun 1962)			
FS-3	AEDC-C	21 Feb 1963 to 23 Feb 1963	SID-62-709		Same as above - Revised Apr 1963			
FSJ-1	L16-ft TWT	4 Mar 1963 to 19 Mar 1963	SID-62-876		"Pretest Report for 0.085-Scale Apollo Force Model FSJ-1, Wind Tunnel Tests in the NASA Langley Research Center 16 ft Transonic Tunnel" (10 Aug 1962) Reissued (11 Jan 1963)			

Table 10. Pressure Tests

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
PS-1	JPL-SWT	12 Mar 1962 to 19 Mar 1962	SID-62-252	5 Apr 1962 PS-CF-62-26050	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Pressure Model (PS-1) of the Apollo in the Jet Propulsion Laboratory 20-in. Supersonic Wind Tunnel and 21-in. Hypersonic Wind Tunnel" (13 Feb 1962)	SID-62-486	4 May 1962 PS-CF-62-27337	"Data Report for Apollo Model (PS-1) Wind Tunnel Test (JPL 20-493B)" (11 Apr 1962)
PS-1	JPL-HWT	2 Apr 1962 to 13 Apr 1962	SID-62-252	5 Apr 1962 PS-CF-62-26050	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Pressure Model (PS-1) of the Apollo in the Jet Propulsion Laboratory 20-in. Supersonic Wind Tunnel and 21-in. Hypersonic Wind Tunnel" (13 Feb 1962)	SID-62-548	1 Jun 1962 PS-CF-62-27889	"Data Report for Apollo Model (PS-1) Wind Tunnel Test (JPL 21-100)" (29 May 1962)
PSTL-1			SID-62-432	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of 0.055-Scale Apollo Transient Pressure Model (PSTL-1)" (28 Aug 1962)			
PS-6	NAA-12-in	2 May 1962 to 12 Jul 1962	NA-62-459		"Pretest Information, NAA Shock Tunnel, Apollo 0.01875-Scale Pressure and Heat Transfer Models" (24 Apr 1962)	SID-62-1072	28 Aug 1962 PS-CF-62-29739	"Data Report for NAA Shock Tunnel Tests (ST-4) of Apollo Command Models H-6 and PS-6" (24 Aug 1962)
PS-4	AEDC-HS II	15 Jun 1962 to 30 Jun 1962	SID-62-538	1 May 1962 PS-CF-62-27256	"Pretest Report for the Apollo Pressure Model (PS-4) in the Arnold Center VKF Hot Shot II" (19 Apr 1962)	SID-62-930	20 Aug 1962 PS-CF-62-29549	"Data Report for Apollo Model (PS-4) Wind Tunnel Test (AEDC Hot Shot II)" (13 Aug 1962)
PS-3			SID-62-777	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the 0.045-Scale Apollo Force and Pressure Models (FS-3) (PS-3)" (8 Jun 1962)			
PSTL-1	TWT	18 Jun 1962 to 9 Jul 1962	SID-62-745	9 Jul 1962 PS-CF-62-28670	"Pretest Report for the 0.055-Scale Apollo Pressure Model (PSTL-1) NAA Trisonic Wind Tunnel" (5 Jul 1962)	SID-62-929	10 Sep 1962 PS-CF-62-29961	"Data Report for Static Pressure Tests of the Apollo PSTL-1 Model in NAA Trisonic Wind Tunnel (TWT 77)" (30 Aug 1962)
PSTL-1	TWT	18 Jun 1962 to 9 Jul 1962	SID-62-745	9 Jul 1962 PS-CF-62-28670	Same as above	SID-62-1151		"Preliminary Report of Transient Pressures Measured on the 0.055-Scale Apollo Pressure Model (PSTL-1) in NAA Trisonic Wind Tunnel"

Table 10. Pressure Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
PS-3	AEDC-A	30 Jul 1962 to 7 Aug 1962	SID-62-752	13 Jun 1962 PS-CF-62-28214	"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC-VKF" (1 Jun 1962)	SID-62-1137	21 Nov 1962 PS-CF-62-31601	"Data Report for the Static Pressure Tests of the Command Module, Launch Escape Vehicle, and Command Module with Service Module (PS-3 Models) in the AEDC-VFK A and B Tunnels " (30 Oct 1962)
PS-3	AEDC-B	7 Aug 1962 to 15 Aug 1962	SID-62-752	13 Jun 1962 PS-CF-62-28214	"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC-VFK" (1 Jun 1962)	SID-62-1137	21 Nov 1962 PS-CF-62-31601	Same as above

Table 10 Pressure Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Letter	Title	Report No.	Transmittal Date, Letter	Title
PSTL-1	A14-ft TWT	6 Aug 1962 to 29 Aug 1962	SID-62-799	9 Jul 1962 PS-CF-62-28690	"Pretest Report for the Transient Pressure Tests of the Apollo PSTL-1 Model in Ames Unitary Wind Tunnels" (21 Jun 1962)	SID-62-1353-1		"Data Report for Static Pressure Tests of the Apollo PSTL-1 Model in the Ames Unitary Plan Wind Tunnels" (26 Dec 1962)
PS-1	A2-ft TWT	20 Aug 1962 to 24 Aug 1962	SID-62-252	5 Apr 1962 PS-CF-62-26050	"Test and Model Information for Wind Tunnel Tests of a 0.02-Scale Pressure Model (PS-1) of the Apollo in the Jet Propulsion Laboratory 20-in. Supersonic Wind Tunnel and 21-in. Hypersonic Wind Tunnel" (13 Feb 1962)	SID-62-1316	20 Nov 1962 PS-CF-62-31576	"Data Report for the Static Pressure Tests of the C/M (PS-1 Model) in the Ames 2- by 2-ft Tunnel" (21 Sep 1962)
PS-3	AEDC-C	6 Sep 1962	SID-62-752	13 Jun 1962 PS-CF-62-28214	"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC VKF" (1 Jun 1962)	SID-62-1242	31 Dec 1962 PS-CF-62-32435	"Data Report for Apollo FS-3 Model Wind Tunnel Test in Tunnel C of the AEDC von Karman Gas Dynamics Facility" (17 Dec 1962)
PSTL-1	AUPWT	10 Sep 1962 to 14 Sep 1962	SID-62-809	9 Jul 1962 PS-CF-62-28670	"Pretest Report for Static Pressure Tests of the Apollo PSTL-1 in the Ames Unitary Plan Wind Tunnels" (22 Jun 1962)	SID-62-1353-1		"Data Report for Static Pressure Tests of the Apollo PSTL-1 Model in the Ames Unitary Plan Wind Tunnels" (26 Dec 1962)
PSTL-1	AUPWT	14 Sep 1962 to 18 Sep 1962	SID-62-809	9 Jul 1962 PS-CF-62-28670	Same as above	SID-62-1353-1		Same as above
PS-3	AEDC-C	21 Sep 1962 to 22 Sep 1962	SID-62-752		"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC VKF" (1 Jun 1962)	SID-62-1242	31 Dec 1962 PS-CF-62-32435	"Data Report for Apollo FS-3 Model Wind Tunnel Test in Tunnel C of the AEDC von Karman Gas Dynamics Facility" (17 Dec 1962)
PSTL-1	AUPWT	1 Oct 1962 to 9 Oct 1962	SID-62-809	9 Jul 1962 PS-CF-62-28670	"Pretest Report for Static Pressure Tests of the Apollo PSTL-1 in the Ames Unitary Plan Wind Tunnels" (22 Jun 1962)	SID-62-1353-1		"Data Report for Static Pressure Tests of the Apollo PSTL-1 Model in the Ames Unitary Plan Wind Tunnels" (26 Dec 1962)
PS-1			SID-62-251	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the 0.02-Scale Apollo Wind Tunnel Models (FS-1 and PS-1)" (28 Aug 1962)			Same as above

Table 10. Pressure Tests (Cont)

Model	Tunnel	Test Date	Tabulated Data Report					
			Report No.	Transmittal Date, Letter	Title	Report No	Transmittal Date, Letter	Title
PS-3	TWT	8 Oct 1962 to 21 Oct 1962	None					
PS-3	AEDC-C	1 Dec 1962	SID-62-752	13 Jan 1962 PS-CF-62-28214	"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC VKF" (1 Jun 1962)	SID-62-1242	31 Dec 1962 PS-CF-62-32435	"Data Report for Apollo FS-3 Model Wind Tunnel Test in Tunnel C of the AEDC von Karman Gas Dynamics Facility" (17 Dec 1962)
PS-5	CAL-ST	17 Dec 1962 to 25 Dec 1962	SID-62-899	17 Jul 1962 PS-CF-62-28840	"Pretest Report for the 0.05-Scale Apollo Pressure Model PS-5 in the Cornell Aeronautical Laboratory Hypersonic Snock Tunnel" (16 Jul 1962)			
PS-1	AEDC-C	4 Jan 1963	SID-62-1385	3 Jan 1963 PS-CF-62-30045	"Pretest Report for the 0.020-Scale Apollo Heat Transfer Models H-1, H-9 and the Pressure Models PS-1 and PS-9 in the AEDC VKF Hypersonic Tunnel "C" (19 Dec 1962)	SID-63-623		"Experimental Heat Transfer and Pressure Distributions Over Entry Configurations of 0.02-Scale Apollo Models H-1 and PS-1 and Hemisphere Cylinders H-9 and PS-9 at Mach Number 10"
PS-9	AEDC-C	3 Jan 1963	SID-62-1385	3 Jan 1963 PS-CF-62 30045	Same as above	SID-63-623		Same as above
PS-3	AEDC-A	1 Apr 1963 to 10 Apr 1963	SID-62-752	13 Jan 1962 PS-CF-62-28214	"Pretest Report for the Static Pressure Tests (PS-3) in Tunnels A, B, and C of AEDC VKF" (1 Jun 1962)	SID-62-1242	31 Dec 1962 PS-CF-62-32435	"Data Report for Apollo FS-3 Model Wind Tunnel Test in Tunnel C of the AEDC von Karman Gas Dynamics Facility" (17 Dec 1962)
PS-3	AEDC-C	7 Apr 1963 to 13 Apr 1963	SID-62-752	13 Jan 1962 PS-CF-62-28214	Same as above	SID-62-1242	31 Dec 1962 PS-CF-62-32435	Same as above

Table 11. Heat Transfer Tests

Test Reports								
			Pretest and Structural Analysis Reports			Data Report		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
H-1			SID-62-330		"Structural Analysis of the 0.020-Scale Apollo Heat Transfer Model (H-1)" (28 Aug 1962)			
H-1	JPL-HWT	16 Apr 1962 to 26 Apr 1962	SID-62-354	12 Apr 1962 PS-CF-62-26572	"Pretest Report for the 0.02-Scale Apollo Heat Transfer Model (H-1) in the 21-in. JPL-HWT" (19 Mar 1962)	SID-62-628	18 Jun 1962 PS-CF-62-28392	"Data Report for Apollo Model (H-1) Wind Tunnel Test (JPL 21-102)" 13 Jun 1962)
H-6	NAA-12-in.	2 May 1962 to 12 May 1962	NA-62-459		"Pretest Information, NAA Shock Tunnel, Apollo 0.01875-Scale Pressure and Heat Transfer Models" (24 Apr 1962)	SID-62-1072	28 Aug 1962 PS-CF-62-29763	"Data Report for NAA Shock Tunnel Tests (ST-4) of Apollo Command Models H-6 and PS-6" (24 Aug 1962)
H-2	AEDC-B	14 Jun 1962 to 16 Jun 1962	SID-62-614	23 May 1962 PS-CF-62-27714	"Pretest Report for the 0.045-Scale Apollo Heat Transfer Model (H-2) in the AEDC-VKF Hypersonic Tunnels B and C" (9 May 1962)	SID-62-993	8 Nov 1962 PS-CF-62-31293	"Experimental Heat Transfer Distribution over Launch and Entry Configurations of an 0.045-Scale Apollo Model (H-2) at Mach Numbers of 8 and 10. Vol. 1, 2, 3, 4, 5, and 6 (Sep 1962)
H-2	AEDC-C	19 Jun 1962 and 10 Jul 1962 to 12 Jul 1962	SID-62-614	23 May 1962 PS-CF-62-27714	"Pretest Report for the 0.045-Scale Apollo Heat Transfer Model (H-2) in the AEDC-VKF Hypersonic Tunnels B and C" (9 May 1962)	SID-62-993	8 Nov 1962 PS-CF-62-31293	Same as above
H-2			SID-62-616	10 Sep 1962 PS-CF-62-29961	"Structural Analysis of the 0.045-Scale Apollo Heat Transfer Model (H-2)" (31 Aug 1962)			
H-4	CAL-ST	17 Oct 1962 to 25 Oct 1962	SID-62-900	17 Jul 1962 PS-CF-62-28840	"Pretest Report for the 0.05-Scale Apollo Heat Transfer Model H-4 in the Cornell Aeronautical Laboratory Hypersonic Shock Tunnel" (16 Jul 1962)	AA-1712-Y-Z		"Hypersonic Shock Tunnel Pressure and Heat Transfer Tests of the Apollo Reentry Vehicle for NAA"
H-2	AEDC-C	28 Nov 1962	SID-62-1214	7 Nov 1962 PS-CF-62-31269	"Pretest Report for the 0.045-Scale Apollo Heat Transfer Models H-2 and HL-1 in the AEDC VKF Hypersonic Tunnel C" (29 Oct 1962)			

Table 11. Heat Transfer Tests (Cont)

Test Reports								
			Pretest and Structural Analysis Reports			Data Reports		
Model	Tunnel	Test Date	Report No.	Transmittal Date, Packing Slip No.	Title	Report No.	Transmittal Date, Packing Slip No.	Title
HL-1 and HL-1B	AEDC-C	29 Nov 1962 to 30 Nov 1962	SID-62-1214	7 Nov 1962 PS-CF-62-31269	Same as above			
H-7	AEDC-F	12 Nov 1962 to 19 Nov 1962 and 29 Nov 1962 to 30 Nov 1962	SID-62-1133	29 Oct 1962 PS-CF-62-31046	"Pretest Report for the 0.040-Scale Apollo Heat Transfer and Pressure Model H-7 in the AEDC-VKF Tunnel F" (24 Oct 1962)			
H-2	LUPWT	16 Jan 1963 to 23 Jan 1963	SID-62-1011	10 Dec 1962 PS-CF-62-32323	"Pretest Report for the .045-Scale Apollo Heat Transfer Models (H-2) and (HL-1) in the Langley Unitary Plan Wind Tunnel" (15 Nov 1962)			
HL-1	LUPWT	24 Jan 1963 to 29 Jan 1963	SID-62-1011	10 Dec 1962 PS-CF-62-32323	Same as above			
H-1	AEDC-C	4 Jan 1963	SID-62-1385	3 Jan 1963 PS-CF-30045	"Pretest Report for the 0.02-Scale Apollo Heat Transfer Models H-1, H-9 and the Pressure Models PS-1 and PS-9 in the AEDC VKF Hypersonic Tunnel C" (19 Dec 1962)	SID-63-623		"Experimental Heat Transfer and Pressure Distributions Over Entry Configurations of 0.02-Scale Apollo Models H-1 and PS-1 and Hemisphere cylinders H-9 and PS-9 at Mach Number 10"
H-9	AEDC-C	3 Jan 1963	SID-62 1385	3 Jan 1963 PS-CF-62-30045	Same as above	SID-63-623		Same as above
HL-1B	AEDC-C	2 Apr 1963	SID-62-1011		Same as above			
H-2	AEDC-C	3 Apr 1963 to 4 Apr 1963	SID-62-1011		Same as above			

VII. REFERENCES

1. Apollo Wind Tunnel Program Report SID 62-170-1 (1 February 1962)

2. Apollo Wind Tunnel Program Report SID 62-170-2 (1 April 1962)

3. Apollo Wind Tunnel Program Report SID 62-170-3 (22 October 1962)

4. Apollo Wind Tunnel Program Report SID 62-170-4 (5 July 1963)